RUDIMENTS OF REASON;

OR, THE

YOUNG EXPERIMENTAL

PHILOSOPHER:

BEING A SERIES OF

FAMILY CONFERENCES;

IN WHICH THE CAUSES AND EFFECTS

OF THE VARIOUS

PHENOMENA

THAT NATURE DAILY EXHIBITS, ARE RATIONALLY AND FAMILIARLY EXPLAINED.

IN THREE VOLUMES.

VOL. I.

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PREFACE.

THERE is, perhaps, no ſtudy more uſeful, nor more entertaining for young perſons of both ſexes, than that of NATURAL PHILOSOPHY; but to be truly ſerviceable, its principles muſt be ſimplified by explanations familiar to their immature underſtandings.

Many and great authors have devoted their labours to the illuſtration of this branch of ſcience, and have done great credit to themſelves, and promoted eſſentially the good of mankind, by their deep inveſtigations on the ſubject. But to underſtand their writings, in which ſo many abſtruſe

and

and technical expreſſions continually occur, implies, and actually requires, great previous knowledge, which cannot be expected from inexperienced youth.

The plan of the preſent Work is calculated to facilitate the acquiſition of uſeful knowledge, by inculcating the rudiments of Natural Philoſophy, and by a plain and eaſy method (hitherto, it is believed, unattempted) introducing the juvenile inquirer to an acquaintance with the ſecret ſprings and movements by which Nature operates, whoſe laws are unerring and invariable.

For the ſake of perſpicuity, and that the memory may not be overcharged by a retention not fairly to be looked for from the tender faculties of youth, the form of Dialogue has been

adopted

adopted for the diſcuſſion; the various ſubjects are arranged under ſeparate heads, and follow in that order which was judged moſt applicable to their connection with each other.

The obſervations of Sir Thomas Howard (the father of the family), which generally introduce each Conference, explain general principles, and are ſuch as will be found neceſſary to prepare the mind for the more eaſily comprehending the various Experiments by which the ſubject is afterwards elucidated.

Theſe Experiments too are ſo contrived as to be in general very readily put in practice by the young ſtudent, as requiring only ſuch apparatus as is either always at hand, or is very readily to be obtained for the purpoſe.

Throughout the Work, as well in the prefatory obſervations, as in the practical or experimental parts of the Conferences, every poſſible attention has been paid to ſimplicity of ſtyle; the moſt familiar and eaſy terms have been always ſelected, and the whole ſubject is placed in that clear and perſpicuous point of view ſo neceſſary in a Work profeſſing, as this does, to reduce the principles of Philoſophy to the comprehenſion of children, or of perſons of moderate capacities.

In ſome places, indeed, it has been found impoſſible to avoid the uſe of certain terms of ſcience, or other words of ſome little difficulty, to which, however, no others could poſſibly be ſubſtituted with the effect of equivalent expreſſion; but of all ſuch words clear

definitions

definitions will be found alphabetically arranged at the end of the Third Volume; ſo as to leave the young Reader without any difficulty, and ſuperſede the neceſſity of frequently adverting to a dictionary for explanations.

That ſome judgment may be formed of the nature of his plan, and the manner in which it is executed, the Editor ſubmits a few ſpecimens, ſelected at chance from different ſubjects. *Phyſics*, for inſtance, is thus treated:

LADY CAROLINE.

"Tell me, my dear, why our brook that winds "through the paddock, was ſo uncommonly "muddy while we were this morning taking "our walk.

MARY.

"It had rained, you know, very heavily, "about an hour before we went out; and the "brook running faſt by a ſand quarry, muſt "have received into its little bed the particles "of ſand, mould, and clay, that the rain car-"ried along with it."

On the Subject of *Motion* we thus treat:

LADY CAROLINE.

" Can you account, Mary, for an amuſe-
" ment which you and I have often ſeen, and
" which the little boys told us was called
" *making ducks and drakes?*

MARY.

" I remember you told me the reaſon of
" it at the time we ſaw them; you ſaid, that
" any ſtone, ſharp round the edges and thick in
" the middle, thrown as obliquely as poſſible on
" the ſurface of the water, riſes at the very
" point where it touched it; becauſe then, on
" account of the ſlantneſs of the jerk, the ſur-
" face of the water does for the ſtone what a
" ſolid and impenetrable plane would do; and,
" if the ſtone has received a ſufficient quantity
" of motion, when its own weight determines
" it again to another oblique fall, it cauſes
" another new reflection, which is often re-
" peated five or ſix times following.

LADY CAROLINE.

" What is the reaſon, Frederic, that an
" oaken board ſtops the force of a ball at once,
" which a ſackful of wool deadens by de-
" grees?

FREDERIC.

" The wood reſiſts at once, and receives in
" the firſt inſtant all the force of the ball;
" whereas the ſack yields little by little, and
" takes many inſtants of time to break the
" efforts of its violence."

Hy-

Hydraulics and *Hydroſtatics* are illuſtrated by Examples like the following;

LADY CAROLINE.

" Tell me, Kitty, how can water be made " to aſcend, even into our very apartments, " for the purpoſe of domeſtic convenience?

KITTY.

" The water that we receive in this extraor- " dinary manner is previouſly preſerved in re- " ſervoirs of a higher ſituation, or runs over a " higher ground than thoſe places to which it " is intended to be conveyed; and this con- " veyance is effected by a continuity of ſloping " tubes, or pipes, lodged under ground, and " directed to their ſeveral deſtinations. As all " water, therefore, endeavours to riſe to a level " with itſelf, it will forcibly mount up through " the pipes of the ſeveral apartments, until it " becomes at laſt equal to the height and level " of the body of water from which it came."

Under the Article *Air*, we reaſon thus;

LADY CAROLINE.

" Of what are the clouds compoſed, Kitty?

KITTY.

" Of certain miſts or vapours, which, when " ariſen to a proper height, become great " maſſes, and are floated by the winds through " the atmoſphere. Such are the clouds which " we ſee ſuſpended on all ſides, and above our " heads, and which occaſionally hide from us " in their courſe, thoſe beautiful objects, the " ſun, moon, and ſtars."

One Example more, perhaps, may ſerve the purpoſe intended, of conveying a juſt idea of the plan of this Work. It ſhall be taken from the Conference on *Sound*.

LADY CAROLINE.

" On touching a bell with one's hand, or any " other ſubſtance, its ſound immediately " ceaſes. Why ſo, Mary?

MARY.

" The ſound is formed by the vibrations of " the particles of the bell, which vibrations are " interrupted by the application of the hand, " or other ſubſtance."

Having premiſed thus much, the Editor has only to expreſs a hope, that his Work will be favoured with the patronage of thoſe ladies and gentlemen particularly, to whom, as conductors of ſchools, or as private tutors and governeſſes, the important charge is committed of training the riſing generation in the paths of Polite Learning.

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PERSONS

ENGAGED IN THE

CONFERENCES.

SIR THOMAS HOWARD.
LADY CAROLINE HOWARD.
GEORGE.
KITTY.
WILLIAM.
ELIZABETH.
HENRY.
FANNY.
MARY.
EDWARD.
SOPHIA.
FREDERIC.

TO THE

YOUNG READER.

AS the following Conferences may demand ſome ſmall effort of imagination on your part, it ſeems neceſſary that you previouſly become ſomewhat acquainted with the ſcene where they were held.

You will, therefore, condeſcend to ſuppoſe yourſelf the inmate or gueſt of a numerous, elegant, and happy family, in a romantic and remote ſpot in Devonſhire. You will then have the ſatisfaction, not only of hearing, but of ſeeing, in idea, the various methods and curious contrivances of Sir Thomas Howard, the moſt vigilant of fathers, and of Lady Caroline Howard, the moſt accompliſhed and affectionate of mothers, to lead a beauteous and obedient offspring through the mazes of nature, to

that

that knowledge which can alone ſatisfy the heart, and do juſtice to ſociety.

You will now imagine yourſelf ſeated with this intereſting party in the midſt of a noble and ſpacious Muſeum.

Pleaſure in every eye, and eager expectation on every young countenance, the firſt Conference is opened by Sir Thomas himſelf; who will, on every occaſion, begin the converſation with laying down an explanation of the rules, and diſplaying the principles which his children muſt afterwards apply to, for the purpoſe of accounting for thoſe *phenomena* which Lady Caroline will afterwards exhibit.

RUDIMENTS
OF
REASON.

THE FIRST CONFERENCE,
ON PHYSICS.

SIR THOMAS HOWARD.

THE knowledge of all thoſe natural bodies which you ſee around you, my dear children, is what is generally meant by the word *Phyſics*.

The object of this ſcience is, to teach us what thoſe bodies are, by their properties, by the effects they have upon our ſenſes, and by the laws according to which they mutually act on each other.

This conſtitutes the principal difference between *phyſics* and *natural hiſtory*; which laſt only tends to inform us, what the productions of nature are, and to point out the ſenſible differences by which they are characteriſed, according to their kinds and their ſpecies.

One thing, my children, I muſt not omit mentioning in the very outſet of this conference; it is, that in the ſcience of phyſics, you muſt never admit of any cauſes but thoſe which are in themſelves true and ſufficient to explain the *phenomenon* in queſtion: and, as this laſt term will frequently recur in the progreſs of our converſations, you ſhould form an early and diſtinct idea of what is meant by it: it is uſed to ſignify the diſpoſition and the motion of bodies, in reſpect of each other; provided this motion and that diſpoſition do not immediately depend on the agency of ſome intelligent being.

One of the firſt queſtions uſually propoſed

poſed concerning bodies, is, whether or not, in ſo vaſt a variety, there be but one and the ſelf-ſame matter?

Much time has been uſeleſsly and unphiloſophically loſt on this ſubject. Thoſe who pretend that all matter is homogeneous (of one kind) ſay, that, in the beginning, the Author of Nature created only one univerſal matter, and that the different bodies were the reſult of the different combinations to which he afterwards ſubjected it.

Thoſe, on the other hand, who maintain that matter is heterogeneous (of various kinds) aſſume, that, in the creation of the univerſe, various principles were formed at one and the ſame time, and that, conſequently, all the elements of bodies are ſo many diſtinct and particular works of the Supreme Being.

But, quitting ſo idle a diſpute, it is enough for us to obſerve, that we com-

monly admit in mixed bodies, of five ſorts of principles, viz.

Sulphur or *Oil*,
Water,
Spirit of *Mercury*,
Caput mortuum, or *dry earth*, and
Salt.

By burning a ſplinter of wood, you may very eaſily diſtinguiſh all thoſe elements.

In the *ſmoke* that ariſes from it, there is *water*; for, on holding your hand in it, you feel it moiſtened.

The *oil* it contained is known by the *ſoot* it leaves in the chimney.

You are convinced of the exiſtence of its *ſpirit* by the *ſharp* impreſſion of the ſmoke on your eye.

In its *aſhes* you find both *ſalt* and *caput mortuum*.

Theſe five elements abound more or leſs in all mixed bodies, and it is on their different mixtures that their variety depends:

I ſcarce

I ſcarce need add, that they are accompanied with a greater or leſs proportion of *air* and *fire*.

The next object you muſt attend to in *matter*, is its *diviſibility*.

Matter is evidently diviſible: but the queſtion has always been, how far this diviſion may be carried? Is it infinite?—For my part, I think the only rational anſwer that can be given on this head is, that, accurately ſpeaking, diviſion is not the deſtruction of matter, and that an infinite number of diviſions can no more exhauſt matter than one diviſion can deſtroy it; conſequently, if an ideal diviſion be meant, matter is moſt undoubtedly infinitely diviſible: but if we mean a real diviſion, it is not; for this reaſon, that ingenuity has leſs power than fancy.

Art, however, my dears, has gone a great way to excite admiration upon this ſubject; and an exact ſcrutiny into the arcana of nature has brought us acquainted

with parts of matter ſo aſtoniſhingly minute, that imagination is loſt in purſuing them. I allude to the

Ductility of Metals,
Diffuſion of Odours,
Exiſtence of Animalculæ, and
Emanation of Light.

Gold-beaters have found the means of giving the matter upon which they are employed, an extent to which you will be hardly willing to give credit. Our great philoſopher Boyle was, I believe, the firſt who obſerved that a quantity of gold weighing only one grain, that is, the four hundred and eightieth part of an ounce, acquires, under their inſtruments, an extent of fifty inches ſquare. Now, the length of one inch contains, at leaſt, two hundred viſible parts; for there are mathematical inſtruments on which an inch is divided into one hundred diviſions, the halves of which are perceivable to an attentive eye. Multiplying then the length by the breadth, a gold leaf of

one

one inch ſquare will have forty thouſand viſible parts on its ſuperior ſurface, with as many more on the oppoſite one, that is, both will have eighty thouſand viſible parts. A ſurface therefore of fifty inches (one grain) will have four million and upwards of viſible parts, which, without much difficulty, a good eye may diſtinguiſh, one grain of gold being but the four hundred and eightieth part of an ounce.

To find the number of the viſible parts of a whole ounce, you muſt multiply four million by four hundred and eighty, and it will give one thouſand nine hundred and twenty million; to which art actually reduces one ſingle ounce of gold.

This ounce of gold leaf, by being drawn on a ſilver cylinder, may likewiſe be, and really is, run out into a length, which, being properly divided, is equal to thirteen hundred and thirty-two miles; and by reducing the miles into fathoms, the fathoms

 into

into feet, the feet into inches, and the inches into two hundred parts, which I have already proved the eye may diſtinguiſh, you will have one ounce of gold extended and divided into one million one hundred and ſeventy-two thouſand one hundred and ſixty fathoms;

Into ſeven million thirty-two thouſand nine hundred and ſixty feet:

Into eighty-four million three hundred and ninety-five thouſand five hundred and twenty inches;

And, laſtly, into ſixteen thouſand eight hundred and ſeventy-nine million one hundred and four thouſand viſible parts!

In this proceſs of wire-drawing, art is but the copyiſt of nature, for the ſilk-worm, by a wonderful inſtinct, ſpins the precious thread with which ſhe forms her *coque* or ſhell.

This thread is of ſo amazing a tenuity, or thinneſs, that having meaſured three hundred yards of it, I found the whole weighed only two grains and a half; ſo that

that there muſt be ſixty thouſand yards to weigh one ounce.

The web of the ſpider, of which I have ſeen made, not only gloves, but beautiful ſtockings, much ſtronger than I could poſſibly have ſuppoſed, is incomparably finer than the production of the ſilk-worm.

To exemplify the diviſibility of matter by

The Diffuſion of Odours,

the moſt ſucceſsful method is, to place a glaſs perfuming pan full, to a certain height, of orange-flower water, or ſpirits of wine charged with lavender, over the flame of a little lamp, or on a few red hot coals: the effect will be, that a copious vapour will be ſeen iſſuing from the pan.

On making this experiment in a *boudoir* fifteen feet every way, I found that in a few *ſeconds* the very ſmalleſt ſpace of the room was charged with the perfume, without any the leaſt viſible diminution of the liquid: now by calculating the air contained in this chamber,

ber, and paying proper attention to every other circumſtance, we ſhall find that the quantity expirated does not really exceed the ſmalleſt grain of ſand; but that by the action of the fire it is divided into five billion, eight hundred and four thouſand ſeven hundred and fifty-two million, eight hundred and ninety-ſix thouſand parts!

This is not all: it is well known that a ſingle grain of muſk preſerves its virtue twenty years without any perceptible diminution. If we ſubſtitute this grain of muſk in lieu of the orange-flower water, it will equally and as immediately fill the aforeſaid apartment with its perfume. Now by renewing the air every day for twenty years, we every day repeat the above-mentioned prodigious number, which we found, by calculation, the room contained; that is, we muſt multiply 5,804,752,896,000 by twenty times three hundred and ſixty-five days, which will give forty-two thouſand three hundred and ſeventy-four billion,

lion, ſix hundred and ninety-ſix thouſand, one hundred and forty million, eight hundred thouſand particles evaporated from this ſingle grain of muſk, without any ſenſible decrement of its ſize.

In the extreme minuteneſs of the members of

Animalculæ

we find another proof of the diviſibility of matter, by the help of microſcopes, particularly the ſolar one.

They have a head which muſt be made up of ſkin, nerves, fleſh, marrow, and membranes. They have a mouth to ſeize, to ſavour, and even to chew their nurture. They have a ſtomach with coats adapted to expanſion and contraction; of courſe it muſt contain the juices neceſſary for the fermentation and digeſtion of the ſubſtances with which they are nouriſhed. They have entrails of different kinds and ſizes, to facilitate nutrition and evacuation. They have eyes to guide and direct them, both in

the

the purſuit of their prey, and how they may avoid becoming the prey of others; and, laſtly, to effect motion and preſerve life, they have veins, arteries, blood, or humours which ſupply its place: An eminent philoſopher, Keil, by an ingenious ſuppoſition, that the particles of the blood of thoſe animalculæ are to the particles of the blood of the human body, as the body of thoſe animalculæ is to the human body, has found by calculation, that a volume of their blood, equal in ſize to a ſcarce viſible grain of ſand, would contain more parts than ten thouſand two hundred and fifty-ſix of the higheſt mountains of the globe would contain viſible grains of ſand.

I ſhall contract the proof of the diviſibility of matter taken from

The Emanation of Light

to one ſingle experiment and calculation.—If you place a wax taper, ſuch as you may have ſix to a pound, in a calm night, and under a ſerene heaven, on the top of a

ſteeple

ſteeple or tower, you will be able to ſee it at the diſtance of ſix miles, that is, the particles it emitted (ſent forth) would fill the capacity of a ſphere of twelve miles diameter. Now, I find by calculation, that during one ſecond of time, there is conſumed only one fourteenth part of a grain of wax, that is, the weight of one ſix thouſand ſeven hundred and twentieth part of an ounce produces every ſecond of time, luminous particles, ſurpaſſing in number the grains of ſand contained in one hundred billion of globes, equal in volume to the ball of the earth.

On the ſubject of

The Void,

I can offer you nothing, my children, very ſatisfactory. Some philoſophers contend that the univerſe is wholly full; others maintain that there are immenſe ſpaces abſolutely empty. Deſcartes ſupports the former opinion; Newton the latter. The

great arguments of Deſcartes and his followers run thus :

Within the four walls of my ſtudy, beſides myſelf, there are books, inſtruments, furniture, fire, and air : as long as the four walls contain theſe things, there is ſpace betwixt them : but let the Deity, by his Almighty power, deſtroy theſe things, ſpace diſappears, and the walls become one body.

Newton's opinion is grounded on the following calculation :

He found that at the height of forty of our miles, the air muſt be a thouſand times more rarefied, or leſs denſe, than on the ſurface of the earth : that at the height of eighty miles, the rarefaction muſt be a million times greater than on the earth ; that at the height of one hundred and ſixty miles, the air muſt be one billion of times more rarefied or more approaching the void, than that which we here breathe. Hence he carries his calculation on to the

moon,

moon, to the planets, to the comets, where he asserts the void to be almost absolute.

For my part, looking on the question as it naturally strikes me, I admit of neither separately. That there is matter with bodies throughout the universe, is evident: it is also very clear that there is space or room for those bodies to move in: the only vacuity therefore can be, the interstices or spaces betwixt these several bodies; and as the particles of which all bodies are formed, undergo various shapes according to their various destinations, so those vacuities will be sometimes greater, sometimes less, sometimes of one form, sometimes of another.

When these interstices are found in one and the same body, fluid or solid, they are called *pores*, of which you may form some idea, by observing the smaller vacuities that necessarily take place in a basket of apples or eggs.

All bodies upon which experiment can faſten are

Porous.

If upon a glaſs cylinder, open at both ends, you place a baſon of any kind of wood, and fill it with water, by pumping the air from beneath it, the water will force its way through the pores of the wood, and fall drop by drop down the cylinder. It is likewiſe owing to this poroſity of bodies, that aqua fortis forces its way by diſſolution through metals; and that air, water, cryſtal, and diamonds, give a free paſſage to light. Marble is ſo extremely porous, that it receives artificial colours ſo intimately as to be taken for the work of nature.

Throughout this and every future Conference, my dear children, I would adviſe you to diſtinguiſh well, and never to forget, three things, with the nature of which I ſhall finiſh this firſt explication, your attention to which has pleaſed me very much.

Theſe

These are,

Mass,
Volume,
Density.

The *mass* of a body is the quantity of gravitating matter which it contains: it is entirely independent of the volume, and is determined by the quantity of the weight.

The *volume* of a body is the quantity of room or space that it occupies: it is independent of the mass, and is determined and known by multiplying the *length*, *breadth*, and *depth* into each other.

The *density* of a body is the relation of its *mass* to its *volume*; so that the greater the mass and the less the volume, the greater the density, which is determined and known by the quotient of the mass divided by the volume.

Specific weight is determined by the density; being the quotient of the absolute weight divided by the volume.

Dilatation

takes place, when the mafs remaining the fame the volume increafes.

Condenfation,

or *compreffion,* takes place when the mafs remaining the fame, the volume decreafes; and

Elafticity

is the effort made by certain compreffed bodies to refume their former fituation.

As a confequence of this laft, you may, for the prefent, fuppofe that gravitation, or the tendency of bodies toward the earth, is a fpecies of elafticity endeavouring to regain its central fituation.

LADY CAROLINE.

Sir Thomas has, with his ufual kindnefs, communicated to you, my children, the principles of a very intereffing Conference. I underftand from him, that it muft be my bufinefs to put your attention to the teft. It fhall be in fuch a manner as to invite an anfwer, in fpite of diffidence; and fhould

that

that anſwer happen to be not correct, it will be Sir Thomas's happineſs to ſet you right.

[*Servants move the Experiment Table before Lady Caroline.*]

I take three ſhort nails, and fixing them in theſe three reſpective holes, ſo that they form a triangle about half an inch in height above the table, I place this half-guinea on the heads of the nails, and lay about half a thimble-full of the flour of brimſtone immediately beneath, and as much upon the half guinea as it can conveniently hold. I now ſet fire to the brimſtone, and beg of you, my dear George, to tell me, in a few minutes, what alteration you obſerve in the half-guinea?

GEORGE.

If I am not miſtaken, Madam, I ſee two half-guineas inſtead of one; and I ſuſpect your Ladyſhip did not obſerve *that* when you began the experiment. Wil you permit me to take it off and examine it?

LADY

LADY CAROLINE.

Certainly, George.

GEORGE.

I proteſt the half-guinea is ſplit into two half-guineas, and what is ſtill more aſtoniſhing, one half is ſo thin, that it ſcarcely carries any impreſſion; while the other looks as if nothing had happened.

LADY CAROLINE.

Well, George, can you recollect any reaſon that may account for this?

GEORGE.

I really cannot.

LADY CAROLINE.

I ſee Kitty ſmiling; ſhe probably may help you.

KITTY.

I imagine that this diſunion in the half-guinea is owing to the pores of the gold, and the different, or, as Sir Thomas called it, the *heterogeneous* matter that invaded them; much in the ſame manner, I ſhould think, as a knife ſeparates a deal board.

The

The more ſubtile part of the ſulphur exhales, and inſinuates itſelf betwixt the pores of the gold, already dilated by the action of the fire, and forms in the boſom of the half-guinea an horizontal layer of matter foreign to the gold, and which I think I can perceive on the two planes that were ſeparated.

SIR THOMAS.

Your anſwer, my dear girl, is very accurate. I ſhall only add a word or two by way of illuſtration.

The very ſame cauſe which diſunites ſurfaces, obſtructs re-union; for this purpoſe oil and lard are generally uſed to hinder a connexion that might otherwiſe be too intimate. Things humid (wet or moiſt) are uſed to prevent the adherence of things adipous, or greaſy; and we employ abſorbent powders when there is upon any ſurface a fluidity that might occaſion an attachment. Thus we employ butter in layers when we roll paſtry. The moulds in which we caſt wax

are

are always ſmeared with ſomething liquid; and in manufactories of earthen ware and china, the new-formed veſſels are always placed upon dry ſand. For this reaſon likewiſe we take care in phyſical experiments to clean and repeatedly dry the ſurfaces we mean to unite.

The experiment her Ladyſhip has ſhewn is entertaining to the natural philoſopher; but in the hands of avarice it becomes dangerous: for the adulteration of coin is often owing to this criminal expedient.

LADY CAROLINE.

While Sir Thomas has been ſpeaking, I have uſed a few drops of warm iſinglaſs to mend the corner of this Tunbridge-ware box; and have beſides melted a few more drops of a compoſition, by means of which I have re-faſtened the ſpout which had been broken off this tea-pot. Tell me, William, how comes it, that a fluid can impart ſuch ſtrength to a ſolid body?

WILLIAM.

WILLIAM.

The iſinglaſs and ſolder which your Ladyſhip employed, by their fluidity inſinuated themſelves into the pores of the bodies to which you applied them, and became a link of union. The ſubſtance of the iſinglaſs is conveyed by means of the water in which it ſwims, ſo as to remain when the water ſhall have evaporated; and when the action of fire ſhall have ceaſed in the ſolder, the ſurfaces are knit together, and by the means of that compoſition, now no more in motion, they are hooked, as it were, by it in every pore, and become one continued body.

LADY CAROLINE.

Here are two cakes of wax, which when I place together adhere very ſenſibly, and that in proportion to the force with which I united them, ſo as apparently to make one body. I now ſeparate them, and pour a thin layer of water on the undermoſt. But you ſee the effect: they no more adhere,

here, and even a conſiderable degree of force will not make them re-unite. What is the reaſon of this, Elizabeth?

ELIZABETH.

It is not the property of water to penetrate unctuous (oily or greaſy) bodies; its very application to them is extremely imperfect, owing to the *heterogeneity*, or the different nature of its elementary parts: and therefore the link of union, mentioned by my brother William, cannot in this inſtance take place by the interpoſition of the water.

LADY CAROLINE.

I have dropped into this tumbler a few thin leaves of copper, on which I pour aqua fortis. What effect do you obſerve, Henry?

HENRY.

I perceive, Madam, a ſlight ebullition, or boiling. The metal ſeems agitated; its volume viſibly diminiſhes; the liquor fumes; it puts on a greeniſh hue; the leaves now wholly diſappear, and there is a

vapour

vapour rises from, and spreads above the glass.

LADY CAROLINE.

You observe well, Henry: can you account as well for your observation?

HENRY.

I fear I cannot: but I recollect Sir Thomas having once told us, that the constituent parts of aqua fortis are sharp pointed, and something like daggers in miniature. The pores of the copper, like sheaths, are ready to receive these spikes, and by the internal heat of the aqua fortis, a violent motion commences, and urges forward the spicula, or darts, with such rapidity, that pore bursting on pore, the immediate destruction of the leaf ensues. The green hue is owing to the mixture of two such substances; and the heat, as well as the vapour that rises above the glass, are the effects of the great motion of the parts upon each other.

LADY CAROLINE.

In this other tumbler, in lieu of copper, I place a portion of ſteel-duſt. Tell me, Fanny, what you obſerve?

FANNY.

It appears to me that the effects are much the ſame as in the laſt experiment: all the difference I can diſcern is, that the movement is more rapid, more violent, and, in place of green, the colour appears reddiſh.

LADY CAROLINE.

Well, Fanny, what is the reaſon of this difference?

FANNY.

I muſt beg leave to aſk your Ladyſhip one queſtion firſt: was the quantity of the file-duſt in the ſecond tumbler equal to the quantity of copper-leaf in the firſt?

SIR THOMAS.

Very well put, Fanny; I wonder her Ladyſhip omitted mentioning that particular.

LADY

LADY CAROLINE.

I am obliged to you, my dear, for attending to the circumſtance. It was.

FANNY.

Then I think that the aqua fortis has a better opportunity of exerciſing its power on the ſteel-duſt than on the leaves of copper: for when matter is equal on both ſides, that which is moſt divided offers moſt ſurface to be acted upon: therefore the aqua fortis being applied at one and the ſame time to a greater ſurface, muſt proportionably diſplay its ſtrength. Beſides, copper being, as I have underſtood, heavier than an equal volume of iron, there muſt be leſs denſity in this laſt, and of courſe more voids; ſo that one ſingle pore may be ſtormed by a greater number of ſpicula, or darts: as for the red colour, I attribute that to the mixture of theſe two ſubſtances.

SIR THOMAS.

It is yet too early to expect reaſons for the production of colours. Theſe will be

given in a future conference On Light. But I have just now a question to put to little Mary, who has not yet had her part in the conference.

Tell me, my dear, why our brook, that winds through the paddock, was so uncommonly muddy while we were this morning taking our walk.

MARY.

It had rained, you know, very heavy about an hour before we went out; and the brook running fast by the sand quarry, must have received into its little bed the particles of sand and mould, and clay, that the rain carried along with it.

SIR THOMAS.

Very well: your answer has been so good, that I must trouble you for another.

Can you account for the flowers in your garden giving a more delicious perfume in the cool of the evening, than in the heat of noon day?

MARY.

MARY.

Is it not becauſe the chillneſs of the evening makes the air ſhrink into itſelf, and gathers together, in any one place, a greater quantity of the ſweet vapours, ſo that we can take in and ſmell a great many of them at once: but in the heat of the day, the rays of the ſun ſpread the air too much, and the perfume having got too much liberty to wander, it is only now and then that our noſtrils are gratified with a ſtray particle?

SIR THOMAS.

Upon my honour, Mary, a very ſingular account this, but a very ſound one, of the compreſſion of the air by cold, and of its dilatation or rarefaction by heat. I ſhall not add a word to it, leſt I might deſtroy the clearneſs and ſimplicity of the anſwer. Once more, Mary: have you not frequently obſerved, that during the great heats of noon, herbs, plants, and flowers, droop ſo much over their ſtems, that they ſeem quite dead;

but that the next morning they re-appear erect in all their former vigorous beauty?

MARY.

This flows from my laſt anſwer. During the day the boſom of the earth cannot ſo quickly ſupply them with ſpirits, as they laviſh their ſweets on the hot ray that exhauſts their eſſence; but when the ſun is down, the excitement ceaſes, and the earth has then time to recruit their pores with a freſh ſtore of juices and repair the conſumption of the day.

LADY CAROLINE.

In this finger-glaſs, which is almoſt full of water, I mix a conſiderable quantity of loaf ſugar, ſo that the water becomes thickened by it: I now pour ſome drops of ſpirits of wine into the glaſs, and it muſt be very obvious to you all, that the ſugar, which before ſwam with the water, is now ſuddenly precipitated to the bottom. What is the reaſon of this, Edward?

EDWARD.

EDWARD.

There is a nearer alliance betwixt the pores of water, and the ſpirits of wine, than betwixt thoſe of water and ſugar. The union, therefore, of the two former is more intimately and ſuddenly effected by a more congenial application of their parts. The ſugar, therefore, muſt of courſe be deſerted, and by its own gravity ſink to the bottom.

LADY CAROLINE.

I have in this cup ſome chips of braſil wood ſteeping in water, and in theſe other cups ſeveral ſmall parcels of plants: if you obſerve, the water in which the braſil wood is lodged, is very highly coloured, and the ſmall knots of fine thread which I have put in the other cups are diſtinctly tinged with many vivid colours. Tell me, Sophia, how this may happen?

SOPHIA.

When the wood is cut from the tree, there are certain juices which dry up be-

twixt its fibres, and are now diſſolved by the penetration of the water, which intermixing with them aſſumes their colour. It is much the ſame thing with regard to the plants. Their dried juices expanding on the approach of the water and carried off by it, are conveyed into whatever ſubſtances it viſits, and when the water evaporates, they again become dry in thoſe ſubſtances, and not only form a part of them, but communicate their colours to them.

LADY CAROLINE.

The water I here uſed was cold, and took ſome time before it drew out the tints: into this cup I pour boiling water, and you may obſerve that the infuſion is more quick and a great deal more deep than in the others: account for this alſo, Sophia, if you pleaſe.

SOPHIA.

The action of fire is here added to that of water; of courſe the liquidity is increaſed, the penetration rendered more eaſy, and the dila-

dilatation of the ſolid allows more room for the exudation of the juices.

SIR THOMAS.

I muſt beg leave to put one queſtion, by the way, to George. How does it happen that the ſtag may be followed by the hounds upwards of ſix hours, and very often without having him in ſight?

GEORGE.

I ſhould imagine, that at the commencement of the chace, the hounds muſt truſt more to ſight than to ſcent; but that after a certain interval a tranſpiration begins on the part of the ſtag, by which the corpuſcula emitted from his pores are conveyed to the noſtrils of the hounds. The longer the run is, the wider the pores are opened, ſo that a greater quantity of corpuſcula are ſent forth; and the longer the hounds purſue the more they are heated, ſo that their noſtrils, the fineſt part of which is generally expoſed to the air, become more open

through

through dilatation and receive a greater portion of the ſtag's effluvia.

LADY CAROLINE.

Frederic, you are very fond of ſalt meat. Salt is almoſt always uſed for the purpoſe of preſerving bodies from corruption. I think I have a right to aſk you the reaſon of this?

FREDERIC.

Corruption is nothing elſe but a diſplacing of parts, which changes the ſtate of the particles of mixed bodies: whatever can keep theſe particles in the order they received from nature, will neceſſarily hinder them from undergoing any unnatural change; and on the contrary, whatever gives place to an unnatural movement will become the cauſe of corruption. Now, ſaline (ſalt) particles, like ſo many wedges, fill up the ſmall vacuities, ſupport and prop the ſolid particles, arreſt the progreſs of evaporation, and preſerve, at leaſt for ſome time, the natural ſtate of the body. It is thus that the

the flesh of animals, when salted, is so long fit for the purposes of society, and that preserves of many kinds may be had on any exigency.

LADY CAROLINE.

I take this lavender bottle, and turning its orifice into this bason of rose-water, I find that it is with difficulty I can raise any part of the water into the bottle. I likewise take this small funnel and fit it to the neck of this other lavender bottle, which it exactly suits: I find that in neither the one case nor the other, the bottles can be filled at once, but that it must be very gradually and slowly effected. Give me the reason of this, William?

WILLIAM.

In both instances, the air in one vessel contends against the water in the other. To introduce any liquid into a bottle, it is necessary that the air should find its way out as the liquor forces its way in. If, therefore, the funnel be so closely applied to the

neck

neck of the bottle that the air cannot get out from between them, either the bottle muſt burſt, or for one drop of liquor that enters, a proportional quantity of air muſt go out; and I believe, that this is the reaſon why the bottle, which is in the hands of the butler who decants it, makes that cadenced noiſe, that the French have celebrated in an *ariette* of imitative harmony. In a word the air contends with the liquid by its elaſticity, and the liquid with the air by its gravity.

SIR THOMAS.

You ſeem, William, ſo much an adept in this ſubject, that I muſt interfere ſo far as to requeſt a reaſon for a phenomenon that very often happens in my cellar. If by the means of a gimlet I make a hole in the lower part of a pipe of wine, not a drop will make its appearance, however the pipe may be urged by motion.

WILLIAM.

WILLIAM.

As there is only that one ſmall orifice, the elaſticity of the air that fills it is much greater than the gravity of the liquor that reſiſts it; therefore things will remain in their original ſtate: but, if an opening be made in the ſuperior part of the pipe, then the elaſticity of the impending air will aid the gravity of the included liquor, and both together will overpower the elaſticity of the inferior and horizontal column of air. This, Sir Thomas, I take to be the origin of vent-pegs.

SIR THOMAS.

I have another queſtion to propoſe to you, William, on the ſame ſubject. After having given a pipe of wine as much air as is ſufficient, and then ſtopping it, the wine flows only during a certain ſpace of time, and dwindles away at laſt into an almoſt imperceptible ſtreamlet, although the pipe be as yet at leaſt half full of wine.

WILLIAM.

In proportion as the wine flows out the inclofed air muft be rarefied and expanded; now, it cannot be rarefied without becoming weaker, the quantity ftill remaining the fame. The greater fpace therefore left by the extracted wine becomes full of a thinner air, which has not force enough to impel the liquor forwards, counteracted as it is by the external column of air which has not felt the dilatation, and, of courfe, is not weakened as the air is, which you ftopped up in the pipe, by its being forced to fill a greater capacity than it otherwife and naturally would.

LADY CAROLINE.

One of my clofet windows, a day or two ago, could not by all the ftrength of the footman's arm be fhut or brought to its former fituation: and I have frequently obferved, Kitty, that the timber-work about the houfe ftarts, cracks, and lofes its juft-

nefs

neſs of proportion. Can you think of any reaſon to account for this?

KITTY.

I have heard Sir Thomas ſay, that it is the nature of all fluids to flow round on all ſides equally, or to run to a level; and as the atmoſphere is in a ſtate of perpetual variation, wood, as well as every other ſpongious matter, undergoes continual alternatives of moiſture and dryneſs, owing to the abſence or preſence of vapours, which muſt neceſſarily cauſe a very great difference in their volumes. A porous ſubſtance at one time increaſes in extent, at another it decreaſes; ſo that every effect of this nature is but the dimenſion of a body increaſed by humidity, or diminiſhed through dryneſs.

LADY CAROLINE.

How has it happened, George, that the wainſcotting of our covered walk down to the grotto has lately bulged ſo very much?

GEORGE.

A ſurface of a ſpongious nature cannot touch a moiſt wall without acquiring an additional extent; and even that ſurface which is neareſt the humidity will become conſiderably more expanded than that which is further from it. Theſe bulgings and diſproportions in joinery would not, I preſume, be half ſo frequent as they are, if it could be contrived to render the increaſe and the decreaſe of ſurfaces at all times equal. In works of one piece, or in thoſe fixed together by means of glue, the change would be ſcarce perceptible, were there heat contrived proportionable to the moiſture; but as it is, one ſide of the wainſcotting becomes humid and larger, while the other remains dry and undiminiſhed; hence clefts, bends, and flaws without number.

SIR THOMAS.

Well, George, what will you ſay to this objection? There are many of the doors in my offices which have warped, without touching

touching or communicating with any humid wall. How does this agree with the account you have given?

GEORGE.

Very well, Sir: for, though the doors in your offices touch no humid walls, they have that to cope with which is much worſe —the diſhoneſty of your carpenters!— They join pieces of wood together which are very different from each other in reſpect of their ſuſceptibility of the impreſſions of the atmoſphere; and while one of the parts of one door might reſiſt moiſture for a fortnight, the other inſtantaneouſly receives it; ſo that while one part remains in its prior ſtate, the other has received a very conſiderable increaſe, and burſts from its original ſituation.

LADY CAROLINE.

What is the reaſon, Elizabeth, that paint is generally uſed on the above occaſions? And how does it counteract the effects of the ever-changing atmoſphere?

ELIZABETH.

By ſtopping up the pores with a ſubſtance impenetrable to water, they not only become impervious to any future moiſture, but that which is already lodged in them cannot get out, or change the diſpoſition of their parts: there ſeems to me to be no other way of hindering the bad effects of humidity, in bodies which can ſuffer no material or viſible alteration, but that which proceeds from moiſture or dryneſs.

SIR THOMAS.

I have frequently been witneſs to a contrivance of a very ingenious nature, and I ſhould be glad to hear Henry give me his opinion of the matter. In the quarries whence mill-ſtones are taken, they cut out a kind of circular ridge round the ſtone they wiſh to ſever from the reſt of the rock; they then fill that ridge with wedges of green-wood, which they have taken care to dry previous to their uſing them, and after driving them in as far as they can go, they

pour

pour water over them. The effect is, that in a very ſhort ſpace of time, the circular ſtone round which theſe wedges were driven ſeparates itſelf from the maſs to which it belonged, without any other effort on the part of the workmen.

HENRY.

The drying of the wooden wedges previous to their being inſerted in the clefts of the ſtone, renders the abſorption of the water afterwards thrown on them ſo quick, that the wood rapidly thereby increaſing in volume, becomes an active principle on the paſſive ſtone, the inactive weight of which muſt conſequently yield to an effort which neceſſarily muſt take place.

SIR THOMAS.

Tell me, Frederic, how is it that in ſummer we perſpire more, eat leſs, and are conſiderably more feeble than in any other ſeaſon of the year?

FREDERIC.

Our perſpiring in ſummer is owing not

only to a greater expanſion of our pores through heat, but alſo to the extraordinary dilatation of the fluids of our body by the ſame cauſe.

As for our then eating leſs than at any other time of the year, it naturally follows for the above reaſon, that the digeſtive powers muſt be, through the loſs of juices, greatly relaxed, and rendered unfit for the exerciſe of their functions.

That we and all other animals are then leſs vigorous, is another effect of the above-mentioned cauſe, heat; with this additional obſervation, that the conſumption of animal ſpirits is at that time greater than the reparatives for appetite, and the need for eating is conſequently not ſo great.

LADY CAROLINE.

Here is an egg, Edward, which five months ago I covered with a ſlight common varniſh, and a thin layer of melted wax: I now break it into this cup, and beg you to give me your opinion of it.

EDWARD.

EDWARD.

I perceive nothing different from a new laid egg; the white and the yolk ſeem to me to be in as freſh a ſtate as ever; and, if I am not miſtaken, the reaſon is, that the ſubſtances your Ladyſhip made uſe of were of a nature to enter the pores of the ſhell, ſo as to hinder the external air from penetrating into the egg, and altering the diſpoſition of its contents, whence would have been produced corruption, and an offenſive ſmell, which in this inſtance is not the caſe; beſides, the evaporation of the ſubſtance within was by the ſame means prevented.

LADY CAROLINE.

Here are two ſtopples, one of oak, and the other of common cork; with them I yeſterday ſhut the orifices of theſe two bottles: the conſequence is, that the liquid in that which was ſhut with the oak has entirely loſt its ſpirit and perfume; but the liquid incloſed by the cork is as ſtrong as

ever.

ever. What can be the reaſon of this, George?

GEORGE.

The more I reflect, Madam, the more am I at a loſs. I really muſt refer it to ſome of my brothers or ſiſters.

LADY CAROLINE.

As none ſeem willing to venture an anſwer, I muſt beg Sir Thomas would aſſiſt us, while we pauſe.

SIR THOMAS.

This is one inſtance to prove how much a trifle may ſometimes puzzle the wiſeſt heads. I have ſeen the ſoundeſt philoſopher put to a ſtand by the moſt obvious queſtion propoſed by a child. In the preſent caſe the fact is very obvious, but the reaſon depends on knowing that the pores of bodies are extremely different. The pores of the oak are large, but at a conſiderable diſtance from each other; to bring them, therefore, nearer together, requires great exertion. The pores of the cork are

exceed-

exceedingly ſmall; but then their quantity makes up for their ſize, for they are innumerable; the diſtance therefore between them, being almoſt infinitely ſmall, the exertion to bring them nearer to each other is proportionably leſs. Now as the neck of a bottle cannot without deſtruction endeavour to bring the pores of the oak to a contiguity, ſo as to hinder the entrance of air, or the iſſuing of the incloſed liquor, the conſequence is, that the ſpirits will neceſſarily evaporate: but, as the pores of the cork are much nearer each other, the neck of the bottle can, without deſtruction to itſelf, ſuffer the condenſation and compreſſion of the pores of the cork into each other, ſo as to effectually hinder either the ſpirits from flying out, or the air from inſinuating itſelf into the bottle.

Permit me now, Lady Caroline, to beg you would diſſolve any ſmall bit of gold you may have about you with a little *aqua regalis*: and then, be ſo good as to try the ſame

liquid

liquid on a piece of ſilver: and while her Ladyſhip is making the experiment, do you, George, attend to it, and account for it.

GEORGE.

I obſerve very clearly that the gold is diſſolved; and I likewiſe ſee that the liquid has had no kind of power over the ſilver. It occurs to me, that the principle you have juſt been giving us, Sir, again takes place in this inſtance. The gold, probably, is ſomething of the nature of the oak, and having large and wide pores, receives without much obſtruction the particles of the aqua regalis, which, when entered, ſeparate the parts from each other, and occaſion diſſolution. The ſilver, of courſe, is of the nature of the cork, and its pores being as ſmall as they are numerous, they cannot admit the too large particles of the aqua regalis; and therefore, as no penetration takes place, no diſſolution enſues.

LADY

LADY CAROLINE.

I have here in theſe two bottles two ſorts of liquids, which I have myſelf prepared in the following manner. As the experiment I am about to make is extremely curious and amuſing, I truſt my children will give a more than common ſhare of their attention to it.

A few days ago I mixed one half ounce of a ſubſtance called *litharge* with ſeven ounces of diſtilled vinegar, and after having boiled the mixture during half a quarter of an hour, I ſtrained it off, and procured a very clear liquor.

I afterwards put into a long-necked bottle one ounce of quick lime, with half an ounce of yellow orpiment, on which I poured ſix ounces of water, and let it remain unmoved during four and twenty hours: it was then ſtrained off, and I procured another extremely clear liquor.

Both of thoſe liquids you now ſee in the bottles before you. I take this new-made

pen, and dipping it in the firſt liquid I write a few lines on this ſcrap of paper, which you may all obſerve diſappear the moment the liquid dries. The paper, you ſee, I put between the firſt and ſecond leaf of Keil's Aſtronomy; it might be placed at the beginning of any book of four or five hundred pages.

I then, as you perceive, dip a ſmall bit of cotton in the ſecond liquid, and turning to the end of the volume, I rub the laſt leaf with a little of what it contains. The book I now ſhut for four or five minutes, and deſire that Kitty may then open it, take out the paper, tell us what ſhe obſerves, and, if ſhe can, account for the appearance.

KITTY.

The paper your Ladyſhip put into the beginning of the book had not one viſible letter upon it; but here I find the firſt line of Satan's Addreſs to the Sun, written in a black-brown colour; and I can perceive no tracks of communication betwixt it and the other

other liquor, as there is not a ſingle mark or ſtain throughout all the reſt of the book.

This is very curious and very ſurpriſing; but I think I remember enough to give ſome kind of reaſon for it.

By ſmelling to the bottle which contains the laſt of theſe two liquids, I eaſily find that the vapour it exhales is exceedingly ſtrong and penetrating, as it affects my noſtrils, even without uncorking it. Now, the vapour of any liquor is only the liquor itſelf divided into very ſmall parts; and if it can pierce through a corked bottle, it certainly can make its way as eaſily through the more porous and ſofter ſubſtance of the paper: but I have often obſerved, that particular colours are formed by the union of particular liquids; and therefore the vapour will make its way by the eaſieſt paſſage it can, which is through the paper, and will only ſtop its progreſs when it comes to be united with the firſt liquor in the beginning of the book; and as the black-brown co-

lour abſolutely depends on the union of both the liquids, or their vapour, no mark or ſtain can be left in any other part of the book, as not one of its leaves was ſuppoſed to be tinged with the firſt liquor.

SIR THOMAS.

My dear Kitty, the accuracy of your reaſons has given me much pleaſure. I have only to obſerve that theſe liquids are generally called *ſympathetic inks*, but have nothing to do with the reveries of the ancients concerning *ſympathetic* and *antipathetic qualities*. The reaſons of the effects produced by thoſe liquids are, as given by Kitty, founded in nature; but the reveries above alluded to are the offſpring of diſordered imaginations.

As a proof of Kitty's judicious ideas of thoſe inks, I muſt mention, that having ſometimes left on a table in the room where I had prepared papers to uſe the next day ſome of the ſecond liquor, I found two or three hours afterwards the characters very legible

legible and diſtinct, which undoubtedly was occaſioned by the vapours flitting through the room, and lighting on the papers already written on with the firſt liquor.

LADY CAROLINE.

Were I to make this ſmall bar of iron red hot, it would become proportionably as it cooled leſs than it was, and harder. How does this happen, Mary?

MARY.

When the bar is red hot, it is greatly dilated, and the violent motion of the fire ſpreads out all its parts, but, as it cools, the pores crowd in upon one another, and as it cools much quicker than it was heated, the compreſſion is greater than the dilatation, and the pores becoming leſs, render the bar at once leſs and harder.

SIR THOMAS.

I have a few uſeful queſtions to put to you, Sophia, on the nature of ſome of the experiments alluded to. Be ſo obliging as to inform me in what this poroſity of bodies conſiſts?

SOPHIA.

It depends upon the manner in which bodies acquire their form, and on the aſſemblage and union of the elements or ſolid particles of which they are made up.

SIR THOMAS.

Some bodies are more porous than others, Why ſo?

SOPHIA.

The elements which enter their compoſition have been ſlower or quicker in uniting together; have been impeded or hurried in the junction, and conſequently are more or leſs intimately connected, which occaſions greater or leſs interſtices and vacuities.

SIR THOMAS.

Has this poroſity of bodies any influence on the different weights we perceive in different bodies?

SOPHIA.

The weight of bodies is wholly dependent on the number or on the ſize of the pores by

by which they are diſtinguiſhed from each other.

LADY CAROLINE.

John has brought me from the cellar a piece of ice, which you ſee I can compreſs with all the eaſe in the world: but the inſtant this flake becomes water, it is then incompreſſible. On the other hand, this bit of wax, of brimſtone, of metal, &c. are all equally ſuſceptible of impreſſion, whether they are in a ſtate of liquidity or not. How is it then, Henry, that liquors have not the property of being compreſſible like ſolids in a ſtate of fluidity?

HENRY.

It occurs to me that the natural ſtate of almoſt all bodies is to be ſolid. They only become liquid by a foreign matter penetrating their pores, and communicating by its ſuperior exertion an unnatural activity which breaks the connection of their parts, and forbids almoſt any kind of adherence. Thus mould when incorporated with a ſufficient

ficient quantity of water, becomes fluid dirt. Water itſelf ceaſes being ice the moment that a more ſubtile fluid, known by the name of igneous matter, has penetrated its parts, and has carried motion enough among them to disjoin them from each other. When, therefore, the queſtion is put, why ſolids may be compreſſed and liquors may not? the anſwer I ſhould offer is, that the foreign matter which gives fluidity to ſolid bodies may be expelled, and by its diſmiſſion from a body to which it does not naturally belong, give room to compreſſion: whereas the fluidity of liquors depending entirely on the conformation and elementary ſimplicity of a matter which is all its own, and without which it would ceaſe to exiſt, its inflexibility becomes its nature; and as there is nothing to be diſmiſſed from it, ſo there is no poſſibility of compreſſion.

SIR THOMAS.

I have tempered this piece of ſteel, William,

liam, that is, I have ſuddenly cooled it in water the moment I took it red hot from the fire; and now, upon breaking it, I find that its grain is wonderfully more coarſe than it was before; I ſhould be glad you ſhould endeavour to account for this: but before you do, I muſt inform you that ſteel is not a particular metal by itſelf; you muſt conſider it in the light of *prepared iron*, although there are mines in which it may be immediately found. The ſort moſt uſed, and, indeed, the fineſt, is that which is made of iron, forged, ſo as to introduce into its pores a certain quantity of ſaline and ſulphureous parts, in order to increaſe its hardneſs, and render it fit for being tempered. By a degree of heat which is immediately given after the ſteel has been tempered, and is called *nealing*, the too great hardneſs acquired in tempering is reduced to a more moderate temperature.

WILLIAM.

I ſhould ſuppoſe that the action of the fire

fire drives from the internal particles of the ſteel a great quantity of the ſalts and the ſulphur contained in it, without forcing them wholly to quit the maſs; for I have often obſerved, Sir, that while you amuſed yourſelf in the fuſion (melting) of mixed and heterogeneous matters, the fire always procured an union of like parts, and therefore when its action increaſes to a certain pitch upon the ſteel, it deprives it of its ſalts and its ſulphur, in ſuch a manner, that when the ſteel undergoes tempering, all its principles, though ſtill the ſame, are variouſly mixed. Previous to its being heated, the ſaline, ſulphureous, and metallic parts, extremely divided, and intimately mixed, made up one whole of a more uniform texture; yet more heterogeneous notwithſtanding, ſince each particle partook of three or four ſeveral ſorts of matters that enter into the compoſition of ſteel: but after a ſufficient degree of fire, the ſalts and the ſulphur drawn forth, and mixed together

ſepa-

ſeparately from the metallic parts, make a more homogeneous whole, though more porous and leſs connected, in reſpect to the globules of ſalts and ſulphur.

I therefore anſwer, that the reaſon why the broken ſteel you hold in your hand appears with a more coarſe grain after being tempered, is, that the metallic particles, which by their colour are the moſt conſpicuous, are gathered together into globules, ſeparated from each other by the ſalts and the ſulphur.

LADY CAROLINE.

Your anſwer, William, has been ſo ſatisfactory to me, that I muſt trouble you with a doubt of my own on the ſubject of tempered ſteel. I have always obſerved, that a piece of ſteel is, after having been tempered, larger than it was before. What is the reaſon of that?

WILLIAM.

I have already obſerved, Madam, that when it is red hot, the commotion within

it

it is exceedingly great, and its conſtituent parts violently torn from each other: the water ſeizing it in this ſituation, checks its returning to its former intimate, more cloſe, and more compact original union.

LADY CAROLINE.

But ſteel, by being tempered, becomes not only larger but harder. How does this happen, Frederic?

FREDERIC.

By what my brother William has already mentioned, I ſhould imagine that ſince the water co-unites all the like particles together, their union muſt be much more perfect than when they were of a more mixed nature, previous to the tempering: now, hardneſs always depends on the degree of union of two conſtituent bodies, and therefore water cannot make that junction more cloſe without making the ſteel harder.

LADY CAROLINE.

Tempered ſteel breaks much eaſier than

that

that which is not tempered. Do you know the reaſon of that, Edward?

EDWARD.

I have underſtood by what has been ſaid, that after tempering, the ſalts and the ſulphur are amaſſed together, and the metallic parts conglomerated into globules: now, as this is the caſe, their ſurfaces cannot touch each other in ſo many points as their particles had done before they had been tempered. A ſeparation muſt of courſe take place more eaſily in one inſtance than in the other.

LADY CAROLINE.

Why, then, George, does *nealing* render the tempered ſteel leſs frangible and more flexible?

GEORGE.

A moderate degree of fire gives, in ſome meaſure, a new exiſtence to the former intimacy of the diſſimilar parts, and recovers what the exceſſive chill had overdone: it is doing nothing elſe but creating, by a mo-

derate fire, a mean ſtate betwixt untempered ſteel and ſteel tempered too much.

LADY CAROLINE.

How is it, Elizabeth, that cold renders a body more elaſtic?

ELIZABETH.

I think it owing to its condenſing it; the parts are then more elaſtic, when they are more tightened, more compact, more ſolid, and more firm: now, nothing ſo much contracts, binds up, and tightens, as cold.

LADY CAROLINE.

And why are bodies much leſs elaſtic in ſummer than in winter?

ELIZABETH.

By the rarefaction of heat, that contraction which occaſions elaſticity in winter, is in a great meaſure loſt in ſummer.

LADY CAROLINE.

I have heard it averred, Fanny, that there is no ſuch thing as perfect elaſticity. Can you tell me why this may be true?

FANNY.

FANNY.

When a body is in the ſtate of unbending itſelf, it ſeems to me to be abſolutely neceſſary that many of its ſolid parts, which mutually touch each other, ſhould repel and withdraw from each other, and that by this means they ſhould ſuffer a very conſiderable degree of friction; this, of courſe, produces a violent obſtacle to motion, and deſtroys a large portion of the ſtrength of the ſpring.

Thoſe bodies which are remarked as having the leaſt pores, which are the moſt poliſhed and the moſt ſolid, are perhaps thoſe which have the greateſt degree of elaſticity, becauſe they then are leſs ſubject to the effects cauſed by friction. Now there cannot be found any mixed body without pores, and therefore the ſpring muſt ever be imperfect through the contiguity and rubbing together of thoſe pores. The only way, therefore, of rendering bodies as elaſtic as their nature will permit,

or of approaching any kind of perfection in this matter, is to hammer them until they become as close, firm, and compact as human industry can make them. By this hammering, their pores become not only less, but fewer in number, the adherence of the constituent particles is made more intimate, the friction of many ill-united surfaces is destroyed, and a great many defects avoided in the delicacy of the instruments in the making of which it is afterwards to be employed.

SIR THOMAS.

It is now, my dears, time to wind up this conference, for your unanimous attention to which I feel sincerest satisfaction, I will close it with a discovery analogous to the subject we have been talking of. It is a species of improvement in the ornamental works of society, which would, if brought to that degree of perfection which it is capable of receiving, add to the splendor of royalty as well as to the elegance of the private gentleman. The account I have taken

taken from the hiſtory of the French Academy: it is a memorial of a Mr. Dufay, who died in 1739, and after his death the writing was found among his papers; but as it was there ſpecified that he had bought the ſecret only on condition that it ſhould not be publiſhed till the commencement of the year 1745, it was not communicated to the academy till the ſpecified time had elapſed.

The invention is, to apply in the eaſieſt manner poſſible, bas-reliefs in gold, on all works of gold and ſilver. The proceſs is as follows:

Four parts of gold-putty extremely pure are taken and amaſſed into a heap upon a porphyry: you make with your finger a ſmall hole in the middle, into which you muſt pour two parts, moſt accurately weighed, of mercury revived with cinnabar.

As ſoon as the mercury is thrown into the hollow made in the middle of the heap,

you muſt pour in after it ſome ſpirit of garlic, which inſtantaneouſly ferments with the mercury and gold; and without loſing one moment's time, you mix and grind together the whole compound with your mullar, until the mixture, becoming dry, is reduced into a kind of grey powder. The quantity of ſpirit of garlic is not determined, and the only inconvenience that ariſes from uſing too much of it, is, that you are obliged to pound it ſtill longer.

To employ this ſingular powder on gold and ſilver, you muſt take great care that the metal be extremely clean, and the gold of the very fineſt quality. If this laſt caution be not attended to, it will become black when put into the fire, which, as you will ſee, the operation requires to be done.

You then rub the piece of gold or ſilver with citron juice: after which dilate or beat up a little of the powder in the ſame juice, and you will apply it to and employ it upon both

both gold and ſilver with an aſtoniſhing facility. You may thicken it to any degree you pleaſe by repeating one layer over another, and allowing the mixture to thicken. A farther convenience is, that when this paſte is dry, you may uſe tools or a chiſſel to cut away any ſuperfluity.

It is right to remark in this place, that when you are going to uſe the powder, you ſhould be provided with a little piece of agate, jaſper, or porphyry, and a ſmall mullar to pound it when mixed with the citron juice, becauſe, ſhould the leaſt lump be left, it very much impedes the uſing of it.

When the powder has been employed on the metal according to the deſign intended, you muſt heat it over a coal fire for the purpoſe of making the mercury evaporate; the more it is heated, the leſs mercury there remains, and conſequently the higher will the gold be in colour: however, it ſtill remains rather too pale, and it were a great improve-

improvement to find ſome method of deſtroying that paleneſs entirely.

When the gold is once become yellow, you rub it with your finger and a little ſmall fine ſand; it will then become burniſhed, and you may carve it and work upon it as upon common gold: the only difference is, that it is a little more ſoft, for which reaſon it is better to work on it with a ſmall chiſel than cut it off with the graver. It ſeldom or never happens that this paſte deſerts the body it was employed upon; when it does, it may be as eaſily replaced as it was at firſt uſed.

I muſt not forget to mention, that you ſhould be greatly on your guard not to let one drop of the ſpirit of garlic fall, for its odour is inſupportable; a drop or two would render a room uninhabitable for many months.

If you ſhould have prepared or beat up with the citron juice more powder than you had

had occaſion to uſe, it can be no more employed after drying; you muſt in that caſe put it in water, where it will precipitate: you muſt waſh in the ſame water the bruſhes, the porphyry, and the mullar which you have made uſe of, and you will find the gold at the bottom, which you may afterwards melt and uſe on another occaſion.

I myſelf have had a proof made of this ſecret, and the watch you all of you ſo much admire, which hangs by Lady Caroline's ſide, is the reſult of the trial.

THE

THE SECOND CONFERENCE.

ON MOTION.

THE young family of Sir Thomas Howard had experienced ſo much ſatisfaction in the former Conference, on their entrance into the moſt pleaſing of ſciences, that with all the ardour of emulation they perſiſted in their importunities till they had obtained a renewal of the converſation.

Sir Thomas had left to Lady Caroline the choice of the ſubject for their ſecond Conference. She well knew it to be his deſire that they ſhould regularly proceed in the ſtudy of nature; and as he had opened the firſt Conference with an account of the ſubject of their future converſations, ſhe conceived that the information her children

had

had obtained of the *body* itſelf of nature, if I may be allowed the expreſſion, ſhould be followed by an inſight into the laws of her

Motion.

The party being met, and Sir Thomas informed of the ſubject propoſed for elucidation, he thus kindly addreſſed his family:

Lady Caroline's judicious choice, my dear children, has been ſuch, that it now claims the higheſt degree of attention. The laws of motion are the groundwork of all natural philoſophy; without a perfect knowledge of them, we err at every ſtep; by underſtanding them thoroughly, we ſhall be able to cope with every difficulty in our way to the ſublimeſt of nature's efforts.

An account of theſe laws demands the utmoſt preciſion. You muſt therefore look forward to Lady Caroline's experiments on the ſubject for that pleaſure which you will amply

amply receive, provided you carry with you a deep impreſſion of the ſhort but comprehenſive truths which I am about to lay before you.

Motion, generally called *local motion*, is the ſtate of a body actually removed from one part of ſpace into the part immediately ſucceeding it; a body with a motion of rotation only has no local motion, becauſe it changes not its place.

Natural philoſophers have eſtabliſhed three great general rules or laws of motion. The firſt is,

Every *body* which is not in motion, *perſeveres* in the ſtate of reſt; and every body which is in motion, *continues* to move in the direction, and with the degree of velocity which it received, until ſome other new *cauſe* forces it to change its ſtate.

Suppoſe a ball in the ſtate of reſt: it will remain perfectly ſtill in that ſtate, until ſome external cauſe gives it motion. Suppoſe another ball in motion; it will con-

tinue to move until an external cauſe forces it to paſs from the ſtate of motion to the ſtate of reſt.

If a ball moves from the eaſt to the weſt, it will continue to move in that direction, until an external cauſe forces it from that direction into another.

If a ball, in the beginning of its motion has, for inſtance, ten degrees of velocity, it will continue to move with ten degrees of velocity, until an external cauſe either increaſes or diminiſhes that velocity.

The reaſon of this firſt law of motion is, That matter or body is, in itſelf, not only indifferent to reſt or to motion, but alſo to ſuch and ſuch a direction, to ſuch and ſuch a velocity.

The ſecond law of motion is, That the change which happens in the motion of a body, is always in proportion to the cauſe which produces it, and continues along the ſtrait line, in the direction of which that cauſe impelled it.

Sup-

Suppoſe a ball in motion, and that a force, or cauſe, capable of giving it two new degrees of velocity, ſhould effect a change in its motion, the conſequence would be, that that motion would be doubled, or become doubly ſwift. This change would likewiſe be made along a ſtrait line; for by the firſt rule, every body tends or endeavours to preſerve the direction it received. The reaſon is ſimply this, that every effect is proportional to its cauſe.

The third law of motion is, That reaction is always contrary to, and equal to action; that is, no action can take place on a body without experiencing a reſiſtance equal to itſelf; and that the actions of two bodies on each other, are always equal and oppoſed in their direction.

This law is true, not only in the caſe of equilibrium, but alſo when an equilibrium does not take place.

Suppoſe two weights perfectly equal in the two ſcales of a balance; the firſt weight

will act as much upon the ſecond weight, as the ſecond weight will re-act upon the firſt weight.

Suppoſe again, that a horſe poſſeſſed of one hundred degrees of ſtrength, draws a ſtone with fifty degrees of reſiſtance; the horſe will not draw the ſtone with one hundred degrees of ſtrength, but with fifty, the reſiſtance of the ſtone deſtroying the other fifty.

The reaſon of all this is, that when forces are at one and the ſame time equal and contrary, they muſt deſtroy each other.

A body is ſaid to move by a ſimple motion in a ſtrait line, when it is puſhed onwards by one force only, or by many forces acting in the ſame direction.

If in equal times it runs through the ſame number of feet, one foot, for inſtance, every ſecond of time, it is then ſaid that it deſcribes its line with a *conſtant and uniform motion*.

Should it run through one foot in the firſt

firſt inſtant, three feet in the ſecond inſtant, five in the third inſtant, it is then ſaid that it deſcribes its line with an *accelerated motion.*

If, on the contrary, it runs through five feet in the firſt inſtant, three in the ſecond inſtant, and only one in the third inſtant of time, it is then ſaid that it deſcribes its line with a *retarded motion.*

The force which produces an uniform motion, is called a *conſtant* and *uniform power:*

And that force which occaſions an *accelerated* or *retarded* motion, is called a *variable* power or force.

The motion of bodies is called *power* or a *moving force,* when it is employed to communicate motion to other bodies, whether it endeavours only to move them, or actually does move them.

A *dead power* is that which is conquered by an *obſtacle*; and a *living power* is that which overcomes a *reſiſtance.*

Absolute rest is the situation of a body which remains in the same part of universal space, or which perseveres in the same relations of situation with the objects which far and near surround it:—and *respective rest* is the situation of a body which preserves and continues to keep one and the same situation in respect to those bodies which immediately environ it.

Compound motion is that by which a body is determined to move by the impulse of many powers, acting at once in different directions upon it.

When this takes place, either the body must remain *in equilibrio*, or it must move in the proportion of the velocities of the acting powers, and receive a direction which proportionably partakes of all the directions of the powers which it obeys.

A body thus set in motion describes a *diagonal*, and a body describes a diagonal when it is impelled at one and the same time by two constant and uniform powers, the direc-

directions of which form an *acute*, *obtuſe*, or *right angle*.

Suppoſe a ball impelled at one and the ſame time by a perpendicular and horizontal power: it will run through the diagonal during the ſame ſpace of time that it would have taken to run over the horizontal ſide, had it been only impelled by the horizontal power, or to fall down the perpendicular ſide, had it been impelled by the perpendicular power alone.

The reaſon is, the ball muſt ſatisfy the two directions it receives; it muſt therefore run through a line common to both thoſe directions: now a diagonal is ever common to the directions of its two ſides, therefore the ball muſt follow the diagonal.

The motion of refraction is that taken by a body on its entrance into a new medium; it then changes its direction, and it is to this change that the name of refraction is given, to ſhew that the direction of the body is as it were broken at that point where the

the two mediums meet and touch each other.

The motion of reflection is that by which a body ſprings back from another which it had met.

If an ivory ball be obliquely thrown on a plane ſurface, it riſes, after ſtriking the plane, and flies to the other ſide, by a motion which natural philoſophers call *reflected*, or by a motion of reflection.

Direct percuſſion is that of two bodies, whereof the *centers of gravity* are in the direction of their motions; in every other inſtance the *percuſſion* is called *oblique*.

I will now lay before you, as briefly as poſſible, the principal laws that nature follows in the ſhock of non-elaſtic bodies.

A moving body which ſtrikes another body at reſt, communicates to it its force in the proportion of the two maſſes. If the body which ſtrikes has a maſs equal to the maſs of the other, it gives it one half of its force: if its maſs is double the maſs of the

 other,

other, it imparts one third of its force; if its maſs be only the half of the other, it communicates two thirds of its force.

A more ſwift body ſtriking a more ſlow body that happens to precede it, divides the exceſs of ſwiftneſs in the proportion of their maſſes, in order to go on together after the ſhock with the ſame or equal velocity. When the body more ſwift overtakes that which is leſs ſwift, the ſlowneſs of the one is an obſtacle to the motion of the other: but this obſtacle is moveable, and muſt partake of the exceſs of velocity of the ſtriking body, in the proportion of its maſs, according to the preceding law.

If two bodies ſhock each other with equal and contrary forces, they ſpring back from each other with the ſame force; for ſince neither is victorious, they neceſſarily muſt recoil with equal powers. Of thoſe powers or forces they loſe nothing, ſince they in no manner communicate them; for it is

obvious,

obvious, that the body that communicates force is the moſt powerful of the two.

If two bodies with contrary directions and unequal forces ſhock each other, they go on together, after the ſhock, towards the ſame place, in the direction of the ſtrongeſt. In this caſe the ſtrongeſt of the two muſt be victorious; for though it does communicate a part of the exceſs of its force, it only divides it in the proportion of the two maſſes, in order to ſurmount every obſtacle to its direction.

The only circumſtance in which two bodies moving in contrary directions remain at reſt, or become motionleſs, is, when, in conſequence of the ſhock, the velocities are in an *inverſe ratio* of the maſſes. On both ſides the forces are kept *in equilibrio*, and this equilibrium produces reſt in both.

Unequal bodies moved in oppoſite ſenſes do not remain at reſt after the ſhock, unleſs their forces be unequal.

A body in motion may, without any percuſſion,

cuſſion, communicate a part of its motion to another body only by preſſure.

The action of a body does not diminiſh its force, nor conſequently its velocity, unleſs it forces the obſtacle, or ſome part of the obſtacle, to change its ſituation.

You ſee, my children, that it is my endeavour to ſhorten as much as poſſible theſe principles of motion, and convert them into brief maxims, that your memories may not have to encounter either confuſion or difficulty.

To the above general laws, I ſhall now add thoſe of elaſtic bodies.

You muſt in the firſt place carefully obſerve, that there are in the ſhock of elaſtic bodies, two kinds of motions: a *direct motion*, by which the elaſtic bodies loſe their former figure; and a *reflected motion*, by which the ſame bodies reſume the figure or form they had loſt.

The firſt law of thoſe bodies is, that in the ſhock *direct motion* is communicated in the

the ſame manner as if the bodies were *hard*: the law of which I have already explained.

The ſecond law is,

When, after the ſhock, two elaſtic bodies reſume their former figure, the body that ſtrikes acquires as much velocity to return back, as it had communicated to the body which it ſtruck; and the body which was ſtruck acquires as much velocity to go on, as it had at firſt received from the ſtriking body.

To illuſtrate theſe laws, let us ſuppoſe two elaſtic balls of equal maſs, and that one of them is motionleſs: let us ſuppoſe, beſides, that the other ball directed towards it ſtrikes it with ſix degrees of velocity; the ſtriking ball will become motionleſs, while the ſtruck ball will fly on in the direction of the former with the whole ſix degrees of velocity. If both theſe balls had been ſimply hard, and not elaſtic bodies, they would have moved onwards, after the ſhock, with three degrees of velocity each; but on account of its elaſticity, the ſtriking ball acquires

quires three degrees of velocity to return back; it muſt therefore remain motionleſs, becauſe it had preſerved three degrees of velocity to go on. In the ſame manner the ſecond ball, as elaſtic as the firſt, reſumes after the ſhock its former figure, and in the act of reſuming it, acquires three degrees more velocity to go on; it muſt therefore proceed with ſix degrees of velocity.

This experiment ſhould be made by balls ſuſpended in the air; for if it be attempted on a plane ſurface, the ſtriking ball will not, after the ſhock, become motionleſs; it will continue to move; you muſt, however, take notice, that this motion is not the direct one the experiment alludes to, but a motion of rotation round its axis, which is totally diſtinct from the other.

If two bodies perfectly ſoft ſtrike with equal forces, they will remain motionleſs after the ſhock: theſe bodies loſe their force, as elaſtic bodies do, and nothing re-

ſtores their forces, as they have no ſpring; they muſt therefore be motionleſs after the ſhock.

Gravity, or weight, is that force by which all bodies fall towards the center of the earth, when unreſtrained by any obſtacle.

Weight is the ſum of the heavy parts contained under the ſame volume.

Central force is that which produces the motion of a body, perpetually endeavouring either to move from or to approach its center of motion.

Centrifugal force is that by which a body endeavours to remove from the center.

Centripetal force is that by which a body is drawn towards, or impelled to, the center.

The ſupporting point of a machine is that *center of motion* around which all the other parts move.

Reſiſtance is the obſtacle or weight which oppoſes the motion communicated by the acting power to the machine.

Power

Power, or *moving* force, is one or many forces joined together, to conquer an obſtacle, or ſupport its effort.

Levers of the firſt ſpecies are thoſe of which the fulcrum lies betwixt the power and the reſiſtance.

In levers of the ſecond ſpecies, the weight is placed betwixt the power and the prop; and in levers of the third ſpecies, the power is betwixt the prop and the weight.

The center of gravity, in a body, is the point around which all the parts of this body are *in equilibrio*, whatever be the ſituation they are placed in.

The center of a figure is the point which divides a body into two equal parts.

The center of heavy bodies is that center of the earth to which tend all ſublunary bodies.

The line of direction of a *weight* is a line drawn from its center of gravity to the center of the earth.

Friction is of two ſorts. *The firſt* is, that

in which the ſame parts of a body are applied in ſucceſſion to the different parts of another; and *the ſecond* is, that in which the different parts of a ſurface touch in ſucceſſion the different parts of another ſurface.

The friction of the firſt ſpecies is exceedingly ſtrong; it cauſes the breaking off of thoſe ſmall prominences which form the inequality of ſurfaces, as one may obſerve by the duſt ariſing from the rubbing together of two pieces of marble or deal. The ſecond ſpecies of friction has by no means ſo much efficacy as the other in abating motion. A billiard ball rolling along a table produces this laſt friction, as well as the wheels of moſt carriages when they are not trigged; for, in this caſe, the friction is of the firſt ſpecies.

Friction increaſes by the increaſe of the ſurfaces, and by preſſure; but more by preſſure than by the augmentation of the ſurfaces.

The

The conſequences of friction are, that owing to it, clothes and moveables can laſt but a certain time; that knives, razors, hatchets, &c. ſoon loſe their edges; that the hardeſt of bodies receive what form the workman chuſes by the friction of the file; and that water-ſpouts never riſe proportionably to the quantity of their motion.

With the foregoing principles, my dear children, you will, ſhould your memory not fail in preſerving them, be eaſily able to account for whatever queſtion Lady Caroline may think proper to propoſe, or for whatever experiment ſhe may be ſo good as to indulge us with.

LADY CAROLINE.

The word *queſtion*, which Sir Thomas has juſt dropped, is a hint, my dears, which I will immediately make uſe of; as a few previous queſtions will not only exemplify the preceding truths, but throw light on many things that may follow.

When a ſtone is thrown againſt a mid-

dling-ſized tree, a very viſible emotion is perceived even in the branches the moſt remote from the trunk; the ſtone then falls at the root of the tree, and remains motionleſs: but if you direct with ever ſo much ſtrength the ſame ſtone againſt a rock, it falls at its root motionleſs as before, without any the leaſt ſenſible ſign of communicated motion. Tell me, Mary, what may be the cauſe of this difference?

MARY.

Every thing material oppoſes its inertneſs to the ſhock of other bodies, and the force with which it reſiſts againſt motion is always proportional to its maſs. Now ſuppoſing that the ſtone was ſent with the ſame ſtrength againſt the tree, and againſt the rock, the firſt, that is, the tree, containing much leſs matter in it than the rock, reſiſted too feebly entirely to conſume the force which urged it to move, without being a little diſplaced; and this diſplacing became viſible by the agitation of the branches.

branches. The rock, having a much larger mafs, refifted completely and victoriouſly; and the effort of the ſtone, diſtributed to a certain number of the parts of the rock, was not ſufficient to extend itſelf to all of them, ſo that the rock could be in no way diſplaced, and of courſe no agitation could be perceivable.

LADY CAROLINE.

How comes it, Edward, that boats are made to advance by the efforts of oars, and why do they advance with ſo much greater velocity as the ſtrokes are more quick and frequent?

EDWARD.

I ſhould imagine, that when the water is ſtruck with ſuch rapidity, it has not time to yield; it becomes by its ſlowneſs a kind of ſupport, or a prop for the lever which the boatman employs. Fiſhes do with their tails the very ſame thing that the waterman does with his oars; the ſwimmer with his arms and his legs, and aquatic birds with their

their feet, which nature has taken care to web in ſuch a manner as to throw back a large volume of water.

LADY CAROLINE.

How, Sophia, do ſwallows, moſt birds of prey, and almoſt all thoſe which haunt water, fly ſo long and ſo far?

SOPHIA.

As they generally have bodies not large, plumage in abundance, and wings extremely long, they are not under the neceſſity of reiterating their vibrations ſo often, and thus, as their fatigue is leſs, their journey may be longer.

LADY CAROLINE.

On the other hand, Sophia, what is the reaſon that ſome birds fly ſo ſeldom, and through ſo ſhort a ſpace: and why do ſparrows, linnets, and all the finch kind, fly, as it were, by leaps, and never ſupport themſelves long in one and the ſame direction?

SOPHIA.

SOPHIA.

The ſhortneſs and unfrequency of the flight of ſome birds is owing to their being too fleſhy, and conſequently to the diſproportion of their wings to the maſs of their bodies; they are therefore obliged to repeat too often the ſtrokes of their wings, which occaſions frequent wearineſs. With regard to the ſparrows, finch kind, &c. their wings are ſo ſhort, that they can raiſe and ſupport their bodies by a velocity, to which they can only give a few inſtants: while they reſt a little in order to re-commence their flight, their own weight gains upon them, and makes them loſe a part of their already acquired elevation; their flight therefore can be nothing but a ſeries of jerks and ſprings.

LADY CAROLINE.

How, Frederic, do certain birds ſupport themſelves during a very conſiderable time (without any appearance of motion in their wings) at the ſame elevation?

FREDERIC.

FREDERIC.

This, Madam, I ſhould ſuppoſe, is what is generally meant by *hovering*: their wings muſt undoubtedly move, but their vibrations are ſo quick and ſo ſhort, that the diſtance renders them undiſtinguiſhable. The great velocity of this motion may for ſome time make up for more extended ſtrokes; but it is to be remarked, that hovering birds are forced, from time to time, to regain by a common flight the elevation they had imperceptibly loſt, and to give relief, by a ſlower and more uniform motion, to the muſcle of which the ſpring had been too much ſtretched by the inconceivable rapidity of their former vibrations.

LADY CAROLINE.

And why, Frederic, do thoſe domeſtic birds, which at certain ſeaſons of the year become very fat, fly ſo little and ſo ill?

FREDERIC.

Becauſe neither their wings, nor the ſtrength to move theſe wings, increaſe in pro-

proportion to their bodies, in order to embrace, as they ſhould do, a greater volume of air: for it is well known, that in every ſpecies, neither conformation nor ſtrength follow the viciſſitudes of plumpneſs.

LADY CAROLINE.

For what reaſon, Henry, is a ball always ſent to a much greater diſtance, than an equal quantity of ſmall ſhot, or leaden drops?

HENRY.

This difference ariſes from the reſiſtance of the air, which always acts in proportion to the ſurfaces offered to it; for each ſmall grain of lead does, as well as the ball, offer to the air which it divides, the half of its round ſurface; and when the weights are equal on both ſides, the ſum of the little hemiſpherical ſurfaces of the leaden drops greatly exceed that of one ſingle ball.

LADY CAROLINE.

What is the reaſon, Elizabeth, of the difficulty which a fiſh experiences in making

ing its way up againſt the current of a river?

ELIZABETH.

I fancy that the fiſh has a double reſiſtance to encounter: one is the motion of the water, which is contrary to the direction of the fiſh; the other is the weight, or rather the inertneſs, of the volume of water to which its body correſponds, and which it muſt diſplace, as much as if the river was a ſtagnant pool. A man who walks againſt the wind, has juſt ſuch another difficulty to ſurmount.

LADY CAROLINE.

In paſſing over a river with a contrary wind, the boatman generally furls his ſail, and begs the paſſengers to be ſeated; for what reaſon, William, does he act ſo?

WILLIAM.

Becauſe by theſe two means he at once diminiſhes the volume of the veſſel, and gives leſs hold to the impetuoſity of the wind.

LADY

LADY CAROLINE.

The wheels of carriages are always trigged in dangerous and rapid deſcents. Why ſo, William?

WILLIAM.

One and the ſame point of the circumference of the wheel being, in this caſe, dragged over a ſucceſſion of reſiſtances on the ground, it becomes a friction of *the firſt ſort*, and is a very conſiderable obſtacle to the motion of the carriage. This will not happen when every wheel turns as uſual on its axle-tree; their different points are then applied to the different parts of the plane over which they roll: this friction, in reſpect of the circumference of the wheel, is of *the ſecond ſort*, and its motion being already very free, would become a great deal too much ſo, were it favoured by too great a deſcent.

LADY CAROLINE.

Why do clothes, furniture, trinkets, in-

ſtruments, &c. laſt only during a certain ſpace of time?

WILLIAM.

The rubbing and friction to which they are perpetually expoſed, gradually change their forms and their ſurfaces, and deprive them of thoſe properties for which they were originally intended.

LADY CAROLINE.

Whence ariſes, George, the very black colour, ſo remarkable in the dirt of the ſtreets of great cities?

GEORGE.

There is a continual and prodigious conſumption in all populous towns of all kinds of iron implements and coals; the particles of iron, as well as of many other black ſubſtances, are, through the friction of conveyance, incorporated with the duſt, which rains have moiſtened, and feet and carriages have beat up into a kind of black mortar.

LADY

LADY CAROLINE.

Why do we, Kitty, rub with ſoap the rim of a box, of which the lid is too tight?

KITTY.

We thereby diminiſh the reſiſtance of the friction, by filling up the pores of the ſurface with a fluid or fat ſubſtance, in order to give a more ſmooth plane, and conſequently leſs hold to the other particles of the rough ſurface. Thus oil is uſed towards facilitating the play of hinges; greaſe is uſed to rub the inſide of the ſtocks of wheels, and by the means of thoſe interpoſed ſmooth bodies, the ſpecies of friction is changed. They are ſo many globules rolling betwixt the ſurfaces, and doing in miniature what we ſee done in a more obvious manner, by rollers placed beneath an immenſe ſtone or a beam, for the purpoſe of making the conveyance more eaſy.

LADY CAROLINE.

Water-ſpouts, Kitty, never are ſeen to riſe to that height to which they ſhould aſcend, conſidering the great quantity of their motion. What can be the reaſon of this?

KITTY.

The water is conveyed through a tube, and has afterwards to make its way through the air, in both which circumſtances it experiences great friction. The internal and immoveable ſurface of the tube delays it on one hand, and when it paſſes into the air, it muſt be looked upon as making its way through another tube, the ſurface of which differs from it only by the thinneſs and the mobility of its parts.

LADY CAROLINE.

How then do you account for the diminution of friction in the internal ſurfaces of large tubes, when their capacity has been augmented?

KITTY.

KITTY.

Although the ſurface of a large tube be greater than that of a more narrow one, it is, however, leſs when compared to its capacity: for it is a thing well known and proved, as I have heard Sir Thomas frequently ſay, that a round and cylindrical tube of two inches diameter contains four times more water than that of which the diameter is only one inch; and that the circumference of the firſt is notwithſtanding only twice as large as that of the latter. Thus if the volume of water, which is four times as much in the greater tube, were contained in four tubes like the leſſer tube, it would correſpond to ſurfaces, of which the ſum would be double the ſurface it already has: and, indeed, the more the capacity of the tubes is diminiſhed in pumps, in aqueducts, and in fountains, the more the velocity of the water is impeded and delayed.

LADY CAROLINE.

Why, Fanny, do rivers flow more ſlowly when their waters are lower?

FANNY.

Becauſe the whole friction of their beds is employed upon a very ſmall portion of water, which thereby has ſcarce any force to urge itſelf on.

LADY CAROLINE.

How is it that thoſe rivers are then moſt rapid when their waters are higheſt?

FANNY.

The friction that they have to encounter from their beds and their banks, is then divided to a more conſiderable maſs of water, and can therefore offer leſs oppoſition to the motion of the fluid. It may be likewiſe ſaid, that the brooks formed by the rain deſcending with rapidity from the ſloping mountains, communicate their ſwiftneſs to the rivers which they enter.

LADY CAROLINE.

In great heats, all the movements of clock-

clock-work are greatly ſlackened. What is the reaſon of that, William?

WILLIAM.

I ſhould think that many cauſes concur in this effect, but the principal cauſe that your Ladyſhip now alludes to, I take to be the increaſe of friction through the preſſure of the pieces which heat has rarefied, and made too large for their ſituation.

LADY CAROLINE.

A piece of metal in the hands of a turner ſometimes ſuddenly reſiſts the motion of the bow, after having, during ſome time, turned with freedom and with eaſe. How does this happen, William?

WILLIAM.

This likewiſe ariſes from the increaſe of friction through preſſure: the metal by being overheated, lengthens between the two fixed points that hold it, and therefore muſt ſtop: to prove which, the readieſt and only uſed remedy is, to drop ſome water over it,

by

by which, being cooled, it turns round with as much eaſe as before.

LADY CAROLINE.

Small pieces of mechaniſm, George, which perform their movements with accuracy and eaſe, are frequently found to be good for nothing when executed on a larger ſcale, although the very ſame proportions be rigidly obſerved. Explain this effect, if you pleaſe?

GEORGE.

Friction does not increaſe in the proportion of the ſurfaces only, but rather in that of the preſſures, which frequently increaſe with the weight or ſolidity of the pieces. A ſurface of more weight or ſolidity preſſes more upon another ſurface; there muſt therefore be more friction, and conſequently more force required to make thoſe pieces act.

LADY CAROLINE.

Why, Mary, are drowned people never picked up at the place where they began to diſappear?

MARY.

MARY.

Becauſe at the ſame time that the weight of their own bodies draws them down, they are forced onwards by the current of the water.

LADY CAROLINE.

All heavy birds, Edward, ſuch as crows, pigeons, magpies, &c. when they wiſh to light on the earth, ſtrive to give themſelves a convex form, by curving their wings and their tail. Can you account for this inſtinct?

EDWARD.

When they bend their tails and their wings, their direction cannot be in a ſtrait line; it muſt form a curve line, which, on account of its greater length, muſt neceſſarily ſoften and break the rapidity of the deſcent: for the figure of any body, conſidered as actually being in a fluid, contributes very much to make that body loſe or preſerve its original direction. If, for inſtance, inſtead of plunging a globe into water, we

ſhould

ſhould uſe half a globe or a hemiſphere; and if this laſt be directed parallel to its fla bottom, as its figure ſtops it more on one ſide than on the other, it will not preſerve its firſt direction, but will deſcribe a curve line, although it moves in a very uniform medium. I have ſeen this often verified by an experiment as ſimple as it is common. Whenever any ſharp-edged body, convex on one ſide, as an oyſter ſhell, is thrown horizontally, it never follows the direction which was given it; and if you turn its convexity downwards, you will almoſt always obſerve it riſe, in defiance of its own weight.

LADY CAROLINE.

The birds we have been ſpeaking of, Sophia, when they are young, drop from the air in a very heavy manner, and frequently hurt themſelves againſt the ground, Why ſo?

SOPHIA.

They deſcend to the earth by a line or in

in a direction that is not ſloping enough, or enough inclined to the horizon, whether it be that they have not reached the maturity of inſtinct that would have taught them to aſſume that convexity of figure which would have ſaved them; or that the feebleneſs of their members, and the ſhortneſs of their feathers, do not allow them to make any effort againſt their fall.

LADY CAROLINE.

Why, Henry, do thoſe who go to ſhoot fiſh in the water, direct the ball always lower than the object?

HENRY.

I think, Madam, that it is becauſe when one ſhoots obliquely or aſlant in the water, the ball, inſtead of deſcending, riſes. Beſides, as we do not ſee the object we aim at, but by the rays of light which come obliquely to us from the water into the air, theſe rays ſuffer a refraction, and do not ſhew the object in its true place. Now as the refraction of light is contrary to the refrac-

refraction of other bodies, the apparent place of the fish is more elevated than its real place.

LADY CAROLINE.

Why, Elizabeth, does a punch, or any flexible piece of pointed iron, when driven into deal, frequently bend from the direction we endeavour to give it?

ELIZABETH.

Its point obliquely meets with some parts harder than others, as it is very easy to observe in fir, in which those kinds of refractions often take place; for should the nail be long and slender, it is not an easy matter to drive it in a strait direction.

LADY CAROLINE.

Why, William, do those who shoot into the water always take care to be very near the place, or direct their shot from an elevated situation?

WILLIAM.

Were they to act otherwise, the direction of the ball might become too oblique, and

and the lead might not even enter the water. A perſon on the oppoſite bank of a river would be in real danger of being wounded; and I have often heard it ſaid, that in almoſt all ſea fights, cannon balls are much more alarming in their execution, by their firſt touching the water, and then darting up by a motion of reflection, than by the original direction that was given them.

LADY CAROLINE.

Can you account, Mary, for an amuſement which you and I have often ſeen, and which the little boys told us was called *making ducks and drakes?*

MARY.

I remember you told me the reaſon of it at the time we ſaw them, and you ſaid that any ſtone, ſharp round the edges, and thick in the middle, thrown as obliquely as poſſible on the ſurface of the water, riſes at the very point where it touched it; becauſe then, on account of the ſlantneſs of the

jerk, the ſurface of the water does for the ſtone what a ſolid and impenetrable plane would do: and if the body has received a ſufficient quantity of motion, when its own weight determines it again to another oblique fall, it cauſes another new reflection, which is often repeated five or ſix times following.

LADY CAROLINE.

Bodies without any ſpring, or thoſe bodies whereof the elaſticity is very imperfect, are much better ſuited to break the effort of violence than any others. What is the cauſe of this, George?

GEORGE.

It is becauſe they gradually retard the velocity of the moving body, and render it motionleſs, by yielding conſiderably at firſt, but leſs and leſs by degrees. Beſides, it is well known that there is no motion, how quick ſoever it may be, which is not effected in a finite interval of time: thus, when a ball drops to form a place for its hemiſphere,

ſphere in ſoft clay, though our ſenſes may induce us to think that the effect took place in an indiviſible inſtant, we muſt, however, conceive the time of the ſinking divided into many equal inſtants; during which, the ſinking ball diſplays its force againſt the parts of the yielding clay. But this force diminiſhes every inſtant, by a proportion which increaſes much more than the time; for, in the ſecond inſtant, the reſiſtances are more numerous than in the firſt, ſince the ball, now more ſunk, offers a greater ſurface to the ſoft clay that it muſt puſh back, but which oppoſes itſelf more forcibly to its being diſplaced, by the compreſſion it has received.

LADY CAROLINE.

What is the reaſon, Frederic, that an oaken board ſtops the force of a ball at once, which a ſackful of wool deadens by degrees?

FREDERIC.

The wood resists at once, and receives in the first instant, all the force of the ball; whereas the sack yields little by little, and takes many instants of time to break the efforts of its violence.

LADY CAROLINE.

A hard body falling on one's hand occasions no hurt, provided the hand yields during the few first instants, instead of bearing up and stiffening itself against it. Give us the reason of this, Kitty?

KITTY.

The yielding hand then deceives, as it were, the falling body, by allowing it more time. Thus a drum resists an infinite number of blows of the drum-stick, although it could not by any means resist one blow alone, equal in force to all those it receives in an hour.

LADY CAROLINE.

What is the reason, Henry, that in order

der to ſtop a boat carried on by the current of the water, you gradually ſlope, and gently wind againſt its ſtrength?

HENRY.

It is for the purpoſe of breaking by degrees the impetuoſity. All obſtacles which yield in this manner, divide the whole effort of the moving body, and arreſt, by a repetition of ſhort attempts, a power which would undoubtedly force them, if all its action were re-united againſt them in one ſingle moment of time.

SIR THOMAS.

On this black and highly-poliſhed marble table I have ſpread, Fanny, an exceeding ſlight layer of oil. I now, you ſee, perpendicularly drop this ivory ball upon it. After having ſtruck the plane of the table, it re-aſcends by the ſame line that it fell, but not quite ſo high; and I obſerve on the face of the table a ſmall round ſpot, of the width of about one twelfth of an

inch. Can you explain this phenomenon, Fanny?

FANNY.

The mark which you have obſerved upon the marble, ariſes from the ſhock and the compreſſion of the parts of one of the two bodies, and probably of both: and as both the ſurfaces are now in the very ſame ſtate they were in before you tried the experiment, there is no doubt but that the parts re-eſtabliſhed themſelves: had this re-eſtabliſhment been perfect, it would have ſent back the ball with a motion equal to that which it had loſt while it fell. This however, in the preſent inſtance, did not take place; as on one hand, the air reſiſted the aſcent, and on the other, it is very likely, that ivory and marble do not re-eſtabliſh themſelves with the ſame velocity with which they may be compreſſed.

LADY CAROLINE.

I ſtrike one of the ſtrings of this guitar, Kitty,

Kitty, and it is not till after it has exhausted a great many balancings and vibrations, that it resumes its former state of rest. Tell me the reason of this.

KITTY.

The motion which sends the body off from its former situation, and continues from side to side during some time, is nothing but the re-establishment of the compressed parts, which will continue till the velocity of the first pressure be spent.

SIR THOMAS.

I have seen, William, cannon-balls, shot horizontally, touch the earth, rebound many times, and leave on the ground tracks of their flight, much *more long than deep*. How does this happen?

WILLIAM.

A bullet follows one curve line in sinking, and another in rising, and these two lines meet at the point of ground where the *descent* ceases and the *reflection* begins. Now, as its velocity in falling is a great deal

deal leſs than its horizontal motion, this laſt motion carries it a great way on, while it has very little time to deſcend to any conſiderable depth. Hence the great difference obſerved betwixt thoſe two dimenſions.

SIR THOMAS.

A cannon-ball loſes all its motion when ſhot againſt a ſtrong tower, or a rampart. What is the reaſon of this, George?

GEORGE.

When one of the two bodies is at reſt, the velocity of the ſtriking body diminiſhes in proportion to the maſs of the body that is ſtruck; motion muſt therefore become imperceptible after the ſhock, if that body which is at reſt is infinitely larger than the body which ſtruck it: for which reaſon the velocity that the ball retains after the blow, is to the velocity which it communicated, as its maſs is to the maſs of the obſtacle which it ſtruck; that is to ſay, as an infi-

nitely

nitely little is to an infinitely large quantity.

SIR THOMAS.

Veſſels are almoſt always daſhed in pieces when they ſtrike againſt a rock; whereas, when the ſhock takes place againſt another veſſel at reſt, the damage is almoſt always inconſiderable.

GEORGE.

As the rock yields not to the motion of the veſſel, the parts of the veſſel which began the ſhock have already loſt all their velocity, while the hinder parts of the veſſel ſtill retain their velocity; a change of figure muſt then neceſſarily take place; the timbers are driven upon one another, and, if the ſhock has been violent enough, break in pieces: whereas, if the veſſel rides up againſt a floating body that receives and obeys its impulſe, the fore parts that are expoſed to the ſhock are not entirely ſtopped, and the hinder parts of the veſſel only

experience

experience a gradual retardation of their velocity.

SIR THOMAS.

A ſmith, Frederic, is always out of humour with too light an anvil, or with one that is placed upon an unſtable flooring. Tell me the reaſon of this.

FREDERIC.

The iron upon which he is employed yielding along with its prop, his blows have not all their effect as they would have if the anvil were ſo immoveably placed as to hold in abſolute reſt the ſide of the iron which touches it, while the hammer ſtrikes upon the other. Workmen, who are obliged to make uſe of the hammer, ſay that the blow was a *falſe one*, when the matter which they uſe ſhrinks from them, by its not being ſufficiently ſupported.

LADY CAROLINE.

Tell me, Fanny, why a hare or a fawn is ſooner ſtopped, and more deſperately wounded,

wounded, when it is ſhot in flank, than when it flies before the aim?

FANNY.

It is becauſe the reſpective velocity of the lead is then greater, and the animal runs in a direction, which does not much remove it from the ſportſman, to whom it then becomes a kind of fixed mark, and muſt conſequently receive the ſhot with all its violence.

LADY CAROLINE.

Why does it require, Edward, a greater effort to *return* a bowl upon a green, than to *ſtop* it by oppoſing one's foot to its paſſage?

EDWARD.

Becauſe you muſt not only employ a force equal to its own to ſurmount its firſt motion, but you muſt likewiſe add all the force that is neceſſary to make it return back. The effort, however, of a moving body which ſtrikes againſt another, may increaſe both by its velocity and by its maſs.

We

We muſt not therefore be ſurpriſed, that tennis players frequently experience their rackets to be too light, becauſe, even in the ſuppoſition that the blow was given with one and the ſame velocity, its effect muſt be a great deal leſs, if the maſs with which it was given was too light.

SIR THOMAS.

The artiſts who work in ſmall rooms, as *planiſhers*, *goldſmiths*, *block-makers*, &c. place the block which carries the inſtrument upon a roll of mat, or ſomething equivalent. What is the reaſon of this, William?

WILLIAM.

It is to deaden the blows; for without that precaution, a great part of the ſtrength impreſſed by the hammer might be tranſmitted to the flooring, and thereby conſiderably endanger the timber works.

SIR THOMAS.

Why, Frederic, are the ramparts of fortified places built with bricks?

FREDERIC.

If thoſe ramparts were conſtructed with any kind of hard ſtone, the cannon balls ſtriking thoſe elaſtic bodies would communicate their motion to a greater depth, abſtracting from the danger of the reflection of the ſplinters.

SIR THOMAS.

And pray, Frederic, can you tell me why piſtols do not carry ſo far as guns?

FREDERIC.

Piſtols are too ſhort for the purpoſes of guns; the lead is already gone forth, before the exploſion of the powder is entirely accompliſhed. The fire, beſides, has not time to pervade all the maſs of the powder.

LADY CAROLINE.

Tell me, Elizabeth, why do not wind and water communicate their motion all at once to moving bodies, as ſolids do?

ELIZABETH.

Solids, having their parts knit together, act with all the power of their maſſes; but

the action of fluids is very different, on account of their parts being ſo very moveable; there is only that part of them which is immediately and directly expoſed to the ſhock, that makes any kind of effort; the reſt does not loſe its velocity, and therefore does not contribute to the general effort. It is only after a certain time that the moving body receives all the motion which may be tranſmitted to it, as one may eaſily perceive in the wings of windmills, and in the wheels of water-mills, at the beginning of their motions.

LADY CAROLINE.

An arrow which offers its point to the reſiſtance of the air which goes before it flies a very conſiderable way, while another arrow, with the current of the air on its ſide, falls almoſt immediately. Explain this effect, Sophia?

SOPHIA.

The arrow which preſents its point only to the air, meeting but very little of that element,

ment, communicates and loſes leſs motion of courſe; whereas the other arrow having to encounter with a great deal more air, which it muſt every inſtant divide for the purpoſe of making itſelf a paſſage, communicates and loſes a great deal more of its force: its motion muſt therefore ſoon ceaſe, and its courſe end.

LADY CAROLINE.

When the extremity of a beam divides the air, why, Mary, may a man carry it with more eaſe?

MARY.

Becauſe it has a leſs body of air to reſiſt when placed endways, than when it is carried ſideways.

LADY CAROLINE.

Why, Kitty, are ladies, on days of ceremony, ſo extremely fatigued with hooped petticoats?

KITTY.

They conſiderably increaſe the volume of

their bodies, and the ladies muſt therefore exert every atom of their force to make way through the additional quantity of air, which their dreſs requires to move in. Eagerneſs, however, and agitation, frequently make them inattentive to the toil, till their return home informs them of it, by the wearineſs of their ſpirits.

SIR THOMAS.

Why, George, does the enſign in a field-day, even when there is not a breath of wind, perſpire and feel extremely fatigued, when not another officer experiences any laſſitude of that nature?

GEORGE.

The colours increaſe the volume of his body; and are beſides extremely remote from the arm which ſupports them: now a weight at a diſtance always acts with more force; and it is never more ſenſibly felt, than when it is *removed* from, and *inclined* to its prop.

LADY

LADY CAROLINE.

Spherical bodies, William, turn round with great facility; what is the reaſon of that?

WILLIAM.

A ball, or a ſphere, touches a plane only in ſome points, and would but touch it in one point, were it perfectly round; theſe bodies, therefore, meeting with little or no obſtacle to their circular motion, and having no hindrance on their own ſurface, it is very obvious that they will not eaſily ſtop, as they meet with ſcarce any friction; and to the little they do meet, they offer juſt as little ſurface; they therefore muſt turn round with great eaſe. Hence the motion of a top muſt continue a very conſiderable time, as it can be ſaid to move only on a point.

LADY CAROLINE.

Why, Mary, does the blow of one ball againſt another give motion to the ſecond?

MARY.

The firſt ball communicates to the ſecond the motion which it had itſelf received from the hand that ſent it off.

LADY CAROLINE.

And pray, why does a ball, when thrown up into the air, ſtop after a certain interval of time?

MARY.

It loſes the force that the hand gave it, by communicating it to the air, which it is obliged to divide.

LADY CAROLINE.

Suppoſe, Fanny, that two men with equal ſtrength threw two bowls, the one upon a uniform pavement, the other on a bowling-green; which would go furtheſt? and for what reaſon would one go further than the other?

FANNY.

The bowl on the pavement muſt certainly run further; for the motion communicated

eated to the ſtones, would be no ſooner given than reſtored to the bowl; whereas the graſs yielding to the other bowl, gradually receives its motion, but does not return it.

LADY CAROLINE.

Why, Mary, do you experience more ſatisfaction in a chariot than in a cart?

MARY.

Becauſe the motion of the wheels and of the horſes are communicated to the ſprings of the chariot, and to the leather thongs which ſupport its body, by the ſlendereſt connexions poſſible, whereas the motion of a cart is in no manner avoided, but fully communicated to the cart itſelf.

SIR THOMAS.

I think, Lady Caroline, that it is now time to put a few queſtions to our little folks, relating to the more curious and intereſting ſubject of *compound motion*; if your

Ladyſhip

Ladyſhip will permit me, I will propoſe one to George.

Why, George, does a waterman, in order to get to the other ſide of a river, direct his courſe to a point much higher than that where he wiſhes to land?

GEORGE.

The reaſon, Sir, ſeems very obvious, when we recollect that the boat forced onwards, in a direction which is not that of the current of the river, forms a motion of its own out of the two forces of which it experiences the action: thus we always ſee, that when the current of a river increaſes, the waterman muſt proportionably exert his ſtrength if he means to arrive at the intended ſpot. If the increaſe of the waters ſhall have made the current much more rapid, the waterman muſt, if he does not exert an equal ſtrength, direct his boat to a point much higher; and this is the general practice uſed by the watermen of the Thames; beſides it is very well known, that

that every moving body, ſuch as a boat, muſt, when impelled by two equal forces at right angles, deſcribe a diagonal.

SIR THOMAS.

To your judicious reaſon, George, I ſhall add a remark or two.

Fiſh furniſh us with very extraordinary inſtances of this compound motion. When they mean to go to one ſide, or to another, they give a ſmart blow to the water with their tails: as the fluid does not inſtantaneouſly yield when ſtruck, it ſerves as a prop to the body of the fiſh, for the purpoſe of turning to the right or to the left; but if the animal had been at reſt, and meant to purſue its way in a ſtrait line forwards, its motion is then always preceded by two very quick blows of the tail, ſtruck in oppoſite directions, the body at that moment receives a motion made up of thoſe two impulſes; it neither goes to the right nor to the left, but its direction is accurately between both.

This

This way of advancing onwards by oblique and oppoſite motions is likewiſe obſerved in almoſt every reptile, ſuch as, adders, vipers, and ſnakes. The adder and the viper have, in ſo very particular a manner, the habit of theſe compound motions, and combine them together with ſo wonderderful an inſtinct, that they not only elude a very quick purſuit, but avoid by the moſt ſagacious windings the moſt diligent ſearch.

Birds alſo, and almoſt all winged inſects, have a compound motion, when they are in the act of turning. The method that inſtinct prompts them to is, to clap one wing, either with more ſtrength, or with more frequency, as you may all obſerve in the flight of a butterfly. Through the variety of its compound motions it is perpetually riſing, falling, winding, ruſhing, and fluttering, all which irregularities you will very eaſily perceive and account for, by the unequal action of its little wings.

When a veſſel, Henry, is in full ſail, if a per-

a perſon from the ſcuttle of the maſt ſhould drop an orange, the people on ſhore would perceive it making a very crooked line in the air, while thoſe on board would aver, that it fell in a ſtrait line, as they really ſaw it fall at the foot of the maſt. Tell me the reaſon of this deception.

HENRY.

The orange has two unequal directions, one of which is horizontal or level with the water, and is occaſioned by the motion of the veſſel: the other is a perpendicular direction, but a great deal ſtronger, and is occaſioned by the weight of the orange. The orange being given up to both thoſe forces, obeys them in proportion to their reſpective powers; and as the horizontal motion of the ſhip is infinitely leſs than the perpendicular motion of the orange's weight, the ſtrait line that it would fall through if the ſhip were at reſt, will belly out, by the motion of the ſhip, into a ſmall curve, beginning

ginning at the ſcuttle, and ending at the root of the maſt.

LADY CAROLINE.

I have ſeen a gentleman, Fanny, toſs up an apple perpendicularly in the air, while he was in full gallop, and without ſtopping, catch it in his hand again. How can this be done?

FANNY.

For the very reaſon, Madam, given by my brother Henry: the apple, in this inſtance is endowed with two unequal impreſſions, and partakes of all the rapidity of the horſe, by the horizontal motion it received from the horſeman: it therefore gives to the forward motion, and to its own weight, as much ſpace as ſuits the inequality of the impelling powers, and by a curve line muſt neceſſarily fall back into the hand that threw it, if the hand remain in the ſame attitude to receive it.

LADY CAROLINE.

My dear Mary, I have often thrown out from

from the window of my carriage, a piece of money, with a desire that it might fall into the lap of a poor person; I have done the same thing when riding with your papa on horseback; I have likewise endeavoured to throw a parcel to a person on shore, as I have been rapidly rowed down the Thames; and on all these occasions, I could never direct the object to the place intended. What could be the reason of this?

MARY.

In all those circumstances, the motion of the carriage, the horse, and the boat, must be as much attended to as the impulse of the hand; for it is as natural and as common to the thing that is thrown, as to the hand that throws it; and I believe that this may be the reason why little Rutland always falls when he leaps out of his carriage at our door, as his impatience will not allow him to wait the opening of the door by his footman, or the stopping of the motion of the carriage by his coachman.

SIR THOMAS.

That allusion, my dear Mary, is an excellent instance of the subject before us; but tell me, Edward, are there no means of avoiding hurt in accidents of this nature in case it were necessary to spring from the carriage?

EDWARD.

The danger does not arise from the too great obliquity of the compound motion, which people might think hinders the body from dropping soon enough to the earth, and thereby escaping the wheel; but the error lies in this, that when a person takes a leap from his carriage in motion, he springs from an unfixed ground; and falsely conceiving that the communicated motion of the carriage is a velocity of his own, he does not exert himself enough to avoid a very unexpected fall.

LADY CAROLINE.

Why does a nut, Sophia, when pressed obliquely, fly from one's fingers, and describe a diagonal?

SOPHIA.

SOPHIA.

As it is equally preſſed by the two fingers, it can no more obey one than the other, it muſt therefore take a mean direction; thus, it is a ſmall motion made up of two impulſes, whereof the effects ſubſiſt, and preſerve their relations to each other, although the cauſes may have ceaſed acting.

SIR THOMAS.

If, Frederic, I ſhould ſtrike this billiard ball with the edge of my hand not perpendicularly on its middle, but perpendicularly on its ſide, it flies forward at firſt as the nut did from the fingers; and after having advanced eight or ten inches, it returns back to a point about half way from that from which it had ſet off. What is the reaſon of this?

FREDERIC.

By ſtriking the ball as you ſaid, it acquires two ſorts of motions, one in a ſtrait line, which it firſt followed, and another of rotation round itſelf, in a contrary ſenſe to

its direct motion; as it happens to a suspended pulley, when its edge is obliquely struck. This last sort of motion is not perceived while the ball glides rapidly over the billiard table; but when the direct motion is sufficiently slackened by friction, the motion of rotation acting in a contrary sense brings it back towards the place whence it departed.

LADY CAROLINE.

Why do the artificial suns in fireworks become larger and more beautiful, by their motion of rotation? Tell me, Mary.

MARY.

The inflamed salt-petre throws out with great force, an infinite number of fiery tangents, and forms a plane much more expansive, than it could possibly be, did it burn without turning.

LADY CAROLINE.

Tell me, Kitty, what is the reason why all swift carriages throw the dirt far from their wheels during their motion?

KITTY.

KITTY.

All bodies indiſcriminately, in whatever ſtate they be, acquire, by turning round, a centrifugal force: thus, the dirt of the roads, not being fixed to the wheel, ſcatters itſelf off; and the grindſtone of the grinder would very ſoon empty the little water trough, in which a part of it is plunged, and would occaſion a continual and incommodious aſperſion, if the grinder did not take care to ſtop the too great quantity of water, that the ſtone would ſcatter, by contriving to place a bit of leather or old hat, ſo as to drag along its ſurface.

SIR THOMAS.

While Lady Caroline has been propoſing the two laſt queſtions, I have ordered John to bring me in this pullet: if you obſerve me, Fanny, all I do to it, you ſee, is, to place its head under its wing, and turn it half a dozen times round itſelf. You perceive the conſequence; it now lies on the table, to all appearance, dead, or dead aſleep. What is the cauſe of this?

FANNY.

Although the pullet may remain motionleſs on the table, after the ungentle exerciſe you have given it, her ſtillneſs is leſs the effect of ſleep, than that of being ſtunned by the confuſion which you have thrown into her ſenſes by the circular motion which you have given them, and which, as long as it laſts, will hinder them from receiving their uſual impreſſions.

SIR THOMAS.

I ſaw, William, a cruel experiment once tried on a favourite dog: they tied him up by his hind legs, and made him turn round himſelf, by means of the rope that ſupported him, a hundred times at leaſt: the conſequence was, an enormous fit of vomiting, and although the creature had not received a ſingle blow, I perceived many drops of blood fall from his jaw. Account for this, if you pleaſe?

WILLIAM.

An exerciſe of this nature muſt greatly derange

derange the animal œconomy, for this very obvious reaſon, that the violence of the centrifugal force determines the fluids to fly towards the head; their natural courſe is conſequently interrupted, and by the ſtrange motion, their functions not only ceaſe, but they likewiſe deſert their appointed ſtations.

LADY CAROLINE.

Is there any danger, my dear Mary, in the amuſement of *ſwinging*, or in that of what is vulgarly called the *roundabout*, more properly the *ring*?

MARY.

There is not; for I have heard my papa ſay, that in thoſe exerciſes, one is ſeated in a ſituation which places the internal parts or the veſſels of the body almoſt parallel with the line round which one turns; that is, with the axis of rotation. But they would both of them be very dangerous, if one ſhould lie in ſuch a poſition, that the length of the body were perpendicular to that line

or

or point round which one turns. It is the ſame thing with regard to the children, who, after forming a ring, run round in purſuit of each other, until giddineſs makes them frequently fall: for by this circular motion the fluids of the brain take a circular direction, and preſerve it ſometimes ſo long, as to be very alarming.

LADY CAROLINE.

I take, Elizabeth, this little ſalver, and ſtrew a quantity of mixed ſpices upon it; I now give it a circular motion, and beg you will tell me what you obſerve?

ELIZABETH.

I obſerve, Madam, that all the ſmaller or lighter ſpices fly to the center of motion, or of the ſalver, and that all the larger or heavier ſpices ruſh round the circumference. The reaſon of this I ſhould ſuppoſe to be, what Sir Thomas has already told us, that the force which drives a body from the center, or the centrifugal force, is greater as the maſs of the body becomes

greater,

greater, when the velocities are on both ſides equal: beſides, the force that draws one body to the center, may be the effect of the force that drives another body from it.

SIR THOMAS.

For what reaſon, Henry, do ſea-faring people ſo cautiouſly avoid all thoſe places on the ſea, and in great rivers, where they perceive the leaſt ſign of a vortex?

HENRY.

Bodies floating on the ſurface of a circulating water being lighter than the ſurrounding waves, muſt neceſſarily be driven to the center of motion. Should a veſſel, therefore, touch the edge of a whirlpool, it would irreſiſtibly be drawn in, and would infallibly periſh: but what is owing to an exceſs of maſs, might in the ſame manner be effected by a greater velocity. A body environed by any matter in circulation, though heavier than that matter, would, notwithſtanding, yield to its centri-

centrifugal force, if that matter turned round much quicker than it; in ſuch a manner, for inſtance, that the degree of velocity in one ſurmounted the ſuperiority of maſs in the other. We have at once an example and proof of this truth, in thoſe whirlwinds which raiſe from the earth, ſtraw, duſt, ſand, &c. for it is always obſerved that thoſe bodies, though much heavier than the air in which they turn, are collected in much greater quantities in the center of the whirlwind (when it begins), and when they have not yet acquired all the velocity of the fluid.

SIR THOMAS.

Here, George, is a tube of very ſtrong glaſs, the diameter is eight twelfths of an inch; I have poured ſome inches of water into it, and after having extracted the air from the remainder of its capacity, I have ſealed it up over an enameller's lamp. You ſee me ſhake it up and down; the water, you may obſerve, riſes all in a maſs to the height

height of ſome inches; and when it falls again to the bottom, its noiſe and its effort is the ſame as that of a ſolid body. Explain this, if you can?

GEORGE.

Had there been air in the tube ſuch as there is in the atmoſphere, from the ſurface of the water to the top of the tube, on ſhaking the water a little, the impending column of air would take its place for a moment, but the water falling back would meet with the air, which would retard its fall, and after a reciprocal diviſion would ſink down, while the air would riſe to its own place; but when there is nothing but water in the tube, and there is no other matter to diſunite it, it falls all together and at once, and the baſe of this liquid column ſtrikes the bottom of the tube juſt as a ſolid cylinder of the ſame weight might do. Our barometer, being a well-made inſtrument, is in the ſame ſituation as the water in your tube. When I take

it

it down, I am always afraid of the glaſs breaking, for the ſuperior part of the tube being empty of air, the mercury acts like a ſolid body againſt the bottom.

LADY CAROLINE.

Why, Sophia, do bodies every day become more or leſs heavy than they were?

SOPHIA.

Becauſe every day takes away or adds to the material particles of which their maſs conſiſts.

LADY CAROLINE.

I have hung up here, Sophia, a ſmall morſel of fine ſpunge on one of the arms of this little balance; and I every day obſerve, that it is more or leſs light or heavy. Account for this if you can.

SOPHIA.

It is owing to its being expoſed to the impreſſions of the air, the moiſture of which frequently makes it heavier, as at other times it becomes lighter by the abſence of that humidity.

LADY

LADY CAROLINE.

Why, Elizabeth, is float-wood lighter than green-wood?

ELIZABETH.

Float-wood has loſt a great part of its ſubſtance, of its ſalts for inſtance; and this is ſo true, that the *lyes* made of its aſhes are ſeldom or ever uſed in waſhing linen, on account of the ſmall quantity of ſalt they contain.

LADY CAROLINE.

We never perceive, Edward, any accelerated motion in the fall of thoſe heavy bodies, to which obſtacles only imperceptibly yield; the weight of a clock, for inſtance, or the weight that turns a ſpit. Can you explain this effect?

EDWARD.

In machines, ſuch as your Ladyſhip mentions, the movement is moderated by means which every moment bring back the moving body to its original ſwiftneſs; that is to ſay, to that infinitely ſmall degree of

velocity with which it would begin to fall, if it were free. To underſtand how a body may a long time continually fall without accelerating its motion, I picture to myſelf a bowl falling down a ſtair-caſe, the ſteps of which are rather large, in ſuch a manner, that falling from the firſt upon the ſecond ſtep, it acquires only as much velocity as is neceſſary to arrive at the brink, by rolling, and then fall upon the third ſtep, and ſo on; it is very evident, that at the hundredth ſtep, its fall will be exactly like that of its firſt ſtep; becauſe, I ſuppoſe, that every time it rolled on the ſurface of a ſtep, it loſt the velocity it had acquired by the preceding fall. Almoſt the ſame thing happens, though not ſo ſenſibly, in the weight of a clock; when one tooth of the balance eſcapes from the pallets, the fuſee turns a little, the cord is let a little down, and the weight falls a little, but ſo imperceptibly, that the eye cannot diſcern it on account of the ſhortneſs of its duration;

tion; this fall, however, is quicker at its end than at its beginning. The reſiſtance experienced by the next tooth, until it likewiſe eſcapes, ſoon deſtroys this ſmall increaſe of velocity, and the ſecond fall is effected like the firſt, that is, as if the moving body had juſt quitted reſt to begin motion.

LADY CAROLINE.

When I take hold of this billet of wood by one of its ends with a pair of tongs, why, Mary, does it riſe up and obey my hand with much more difficulty than when I take it by the middle?

MARY.

When your Ladyſhip takes it by one end, the other has ſo much the more force to reſiſt, as it is more diſtant from the tongs, and conſequently from the *prop*, or point of ſupport; and I take this to be the reaſon why the longer the planks are on which we play at *ſee-ſaw*, ſo much the more eaſily do they bend.

LADY CAROLINE.

Why, Kitty, does a carpenter, who is about to carry a heavy joiſt, always place it on his ſhoulder as near the middle as he can?

KITTY.

By thus placing it, he has only the weight of the wood to carry, becauſe the two ends balance each other; and the prop is only loaded with the ſum of the two maſſes; but if he had placed it at the two-thirds, or at the three-fourths of its length, to keep it from falling he would be obliged to hold down with his arms the ſhorteſt end; and this effort would then balance the greater length of the joiſt on the oppoſite ſide; but it is very evident that he charges his ſhoulder with this additional weight only through ignorance.

SIR THOMAS.

Why, Fanny, does that gardener I ſee from the window in the paddock, ſtoop ſo much forward, while he is pulling (by means

means of a rope) that tree to the hole he has prepared for it?

FANNY.

I think, Sir, that to the exertion of the muſcles he adds a part of the weight of his body, to conquer the reſiſtance againſt which he acts. But it ſeems to me that he has injudiciouſly choſen his ground; for I know the place he ſtands upon is an aſcent, and a ſlippery one too; and, as he has no better prop, I doubt it will be a pretty conſiderable while before he will draw the tree to its deſtined place.

I ſuppoſe, it is to prevent inconveniencies of this nature, that aſhes are generally thrown on froſt-glazed places much frequented, and that ſtrong points are affixed to horſe-ſhoes during great froſts.

SIR THOMAS.

The inhabitants of the more northerly regions, being almoſt always obliged to travel on ſnow, bind to their feet a kind of racket, a great deal longer and broader than

any of our ſhoes. What is their intention in this, William?

WILLIAM.

By this contrivance they take in a greater portion of the plane, or of the ſurface they walk on; the breadth of which ſupplies the want of ſolidity with a more extended prop.

LADY CAROLINE

What is the reaſon, Kitty, that horſes are ſo extremely fatigued with the labour of ſurmounting an aſcent?

KITTY.

It is not only the burthen, which is then leſs ſupported by the ground, but it is, beſides, the proclivity of this ground which offers them a prop, in a direction extremely oblique to their exertions; for their legs labouring againſt it, incline in the ſame ſenſe as it does; and the more parallel they become, the leſs are the feet ſupported. For which reaſon, in roads of this nature, winding inequalities are from time to time dug, for

for the purpoſe of facilitating the draught; imitating, in ſome ſenſe, the ſteps of our ſtairs, which, preſenting a horizontal plane to the vertical effort of the foot, are much better props, and ſurer points of ſupport, than any portions of the inclined plane upon which they are built.

SIR THOMAS.

Why, Frederic, are large wheels generally preferred to ſmall ones?

FREDERIC.

The levers of the large wheels are longer, and every point of their ſtocks, which are inceſſantly pulled, lies in the direction of the traces, and at the height of the breaſt of the horſes. Hence, as I have read that the carriages of our anceſtors had four large equal wheels, they were much more uſeful than ours, which have only two high, and two other low wheels. Four large equal wheels are four large levers, continually ſeized by their extremities, and urged on in a direction perpendicular to the traces.

LADY

LADY CAROLINE.

Then why, Sophia, do we put two ſmall wheels to our carriages?

SOPHIA.

I ſhould think, Madam, that it is to hold the fore part of the carriage in a kind of ſuſpenſion, that the very firſt exertion of the horſes, in a difficult paſſage, may tend to raiſe up the front, in order to facilitate the diſengaging of the back part of the vehicle.

SIR THOMAS.

Since an inclined plane is always longer than a vertical one, both heights being ſuppoſed equal; and conſequently, ſince a ſtair-caſe, a gentle ſlope, a ladder obliquely raiſed, do not lead to any particular elevation by the ſhorteſt way, why, Henry, are thoſe means, however, every day fixed upon in preference to others, by which much time might be ſaved?

HENRY.

When planes of this nature are choſen for

for the purpoſe of raiſing bodies (pipes of wine, for inſtance, from a cellar), the additional time employed is leſs a loſs than a change of velocity into force; for, if the inclined plane delays the velocity of the deſcending bodies, there is required leſs effort to ſtop their fall; and when they are thus ſupported, their weight is always more eaſily ſurmounted, whether it be meant to leave them at reſt, or to raiſe them up again. Beſides, it is well known, that it is more eaſy to raiſe a body by a line parallel to a plane, than by any other direction.

LADY CAROLINE.

There are ſome edifices, Mary, which, though their perpendicularity be loſt, ſtill ſupport themſelves, and bid defiance to ſtorms and time. How can this happen?

MARY.

I ſuppoſe, Madam, that their center of gravity is ſtill in the right direction, and equably ſupported.

LADY

LADY CAROLINE.

Why, Fanny, do rope-dancers perpetually gesticulate with their hands and arms?

FANNY.

Because the body they walk on being continually in motion, as well as inclined, whenever they perceive that the center of their motion is not supported, they recover it into the line of its direction by extending an arm on the opposite side, using it as a lever, of which the weight is so much the more powerful, as its parts are more distant from the center of their motion.

SIR THOMAS.

Why, George, do corpulent people generally lean back?

GEORGE.

In any other attitude, their center of gravity not being well enough supported, they would risk falling on their face. This inconveniency is particularly owing to the prominence of their anterior parts.

SIR

SIR THOMAS.

Then why does a porter, with a load on his back, ſtoop forwards?

GEORGE.

He and his burthen have one common center of gravity, which is ſeldom or ever placed within the body of the porter, and which would be inſtantaneouſly loſt, if he attempted to walk erect. He muſt therefore neceſſarily ſtoop forward, until this center of gravity is ſituate in a line directly betwixt both his feet.

SIR THOMAS.

And why, George, is a weight moved to and fro with ſo very little difficulty, when its center of gravity is ſuſpended in the air?

GEORGE.

There are then neither the frictions of a rough ſurface to get the better of, nor the force of weight to ſurmount.

LADY CAROLINE.

All two-footed animals have their bodies

dies inclined forwards when they walk, and turn them alternately to the right and to the left. Why does nature prompt this motion, Kitty?

KITTY.

As the line of direction always passes through one foot, while the other is in the air, the center of gravity where the line of direction originates is supported by that foot. If this center was not supported, both by stooping forwards, and by collateral endeavours, it would unavoidably tumble, and, reasonable or not reasonable, would bring down the biped in its fall.

LADY CAROLINE.

Small birds, Mary, perched of a night on a tree, cling to a branch with only one foot, contract the other up under their plumes, and then turn their head to the opposite side, to nestle it under the wing, and sleep with tranquillity. How is this managed?

MARY.

MARY.

They act so that the line of direction may pass through the foot that clings to the branch, and that the center being supported on one foot may no more incommode them. This they effectually do by the contracted foot keeping a perfect balance or equilibrium with the inverted head.

SIR THOMAS.

How is it, Edward, that where politeness induces us to incline the superior part of the body and bend the head forwards, natural mechanism, as well as politeness, makes us advance one foot before us?

EDWARD.

That the line of direction may pass through that foot, for the purpose of supporting the center of gravity, lest an excess of civility might send us a little lower than we intended; as it would most unavoidably happen to whoever should attempt to pick up a pin from the ground with his two heels close to the wall.

SIR THOMAS.

The center of gravity in a four-footed animal, for inſtance, the horſe, Henry, is ſomewhere about the middle of his belly, and ſeems to be ſupported by nothing. How comes it that, even in full gallop, he does not fall?

HENRY.

In the horſe, the center of gravity is ſupported in the ſame manner that the ſolid diagonal is, which is the prop of the whole maſs; I allude to two legs, the fore right leg, and the hind left leg, ſince both of thoſe going always alternately to the ground, ſupport the ſolid diagonal that tends from one right leg to another left leg, and to which the center of gravity correſponds.

LADY CAROLINE.

Why, Frederic, may thoſe bodies, whereof the baſes are more expanded, remain for many years hanging over them without danger?

FREDERIC

FREDERIC.

While the line of direction paſſes through the baſe, the center of gravity ſupported by it cannot fall: and while it cannot fall, the parts around it, being well cemented to it, and to one another, remain eternally attached to it, if I may uſe the expreſſion.

Hence the famous towers of Bologna and Piſa, the hanging ſummits of which ſeem every moment threatening ruin, ſubſiſt ſtill, and bid defiance to the united efforts of weight and wind.

SIR THOMAS.

I have ſeen a cat thrown down from a three-pair-of-ſtairs window into the ſtreet; and though, in the firſt inſtants of its fall, its legs were turned upwards, yet it fell upon its four feet without receiving the leaſt hurt. How did this happen, William?

WILLIAM.

The cat, ſuddenly ſeized with a natural fear, bent the bone of its back, ſtretched its belly, lengthened out its feet and its

head, as in the effort and attitude of regaining the ſituation it came from. In this extraordinary motion, the center of gravity mounts above the center of the figure, but, not being ſupported, ſoon deſcends. While it deſcends to place itſelf beneath the center of the figure, it turns towards the earth the belly, the head, and the legs of the cat; the fall of which is then ſo near the ground, that, inſtead of being even ſtunned, it flies off with all the rapidity that fear can prompt.

LADY CAROLINE.

In a boat, Sophia, I have frequently been in danger of falling at full length, when it chanced to hit too ſuddenly againſt the ſhore. What is the reaſon of that?

SOPHIA.

While the boat recoils, the fore part of your body ſtill preſerves its firſt direction towards the ſhore. Your feet, inaſmuch as they belong in a manner to the boat by your ſtanding upon it, receive from it a contrary

contrary direction of going back. Your body obeys both the directions as well as it can; the feet go back, the head plunges forward, and the middle of the body, having no ſupport, falls.

SIR THOMAS.

If a perſon be placed upon a cylinder and endeavours to leap forward, he falls. Why ſo, George?

GEORGE.

He gives his head a forward direction, while the round cylinder gives his feet a backward one; the head and feet follow of courſe their reſpective directions, and the body, by its fall, proves the experiment.

LADY CAROLINE.

I have ſtuck into the two ends of this dry ſtick, about three feet long, and as thick as my wriſt, two pins; I now place two glaſſes, half full of water, on thoſe two tables of equal height, diſtant about three feet from each other. I place the ſtick in a horizontal ſituation, ſo that the two pins

bear upon the borders of the two glaſſes; I now beg of Sir Thomas to ſtrike a violent and quick blow on the very middle of the ſtick. You ſee that the ſtick is broke in two, how thick ſoever it was; and how fragile ſoever the glaſſes are, they are not only not broken, but not a drop of the water is ſpilt. Had I ſuſpended the ſtick by two threads, the effect would have been the ſame. Account for this, William.

WILLIAM.

The middle of the ſtick, I mean the point that was ſtruck, compreſſed itſelf and at once received the inſtantaneous impreſſion of the blow: this impreſſion by communication paſſes on ſucceſſively to the other parts of the ſtick, but too ſlow to relieve the center of the ſtick, It therefore breaks, but breaks in obſerving every law of motion that its ſituation demands. It cannot remove the maſs of air beneath it; it cannot communicate its motion to any other yielding body contiguous to it, ſoon enough

enough to avoid fracture; it therefore at once yields, before even the pins have been in the leaſt affected by the ſtroke; one may look on the glaſſes as on two props; the middle of the ſtick, as the extremities of two rays, and the blow as the power applied to thoſe extremities. The more they are diſtant from the glaſſes or from the props, the more force they receive to deſcend beneath the blow: but the extremities near the glaſſes ariſe by the deſcent of the middle ones, and riſe ſo as not only to precipitate the fracture, but to ſave the props or glaſſes.

END OF VOL. I.